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INSTRUCTIONS

FOR

MODEL V-2000

VARIABLE DC VOLTAGE STANDARD

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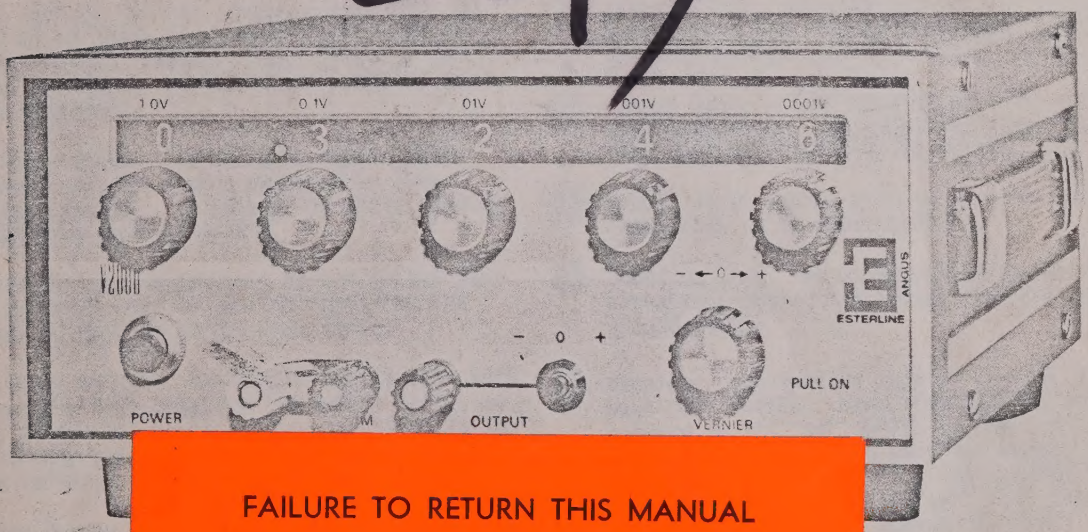

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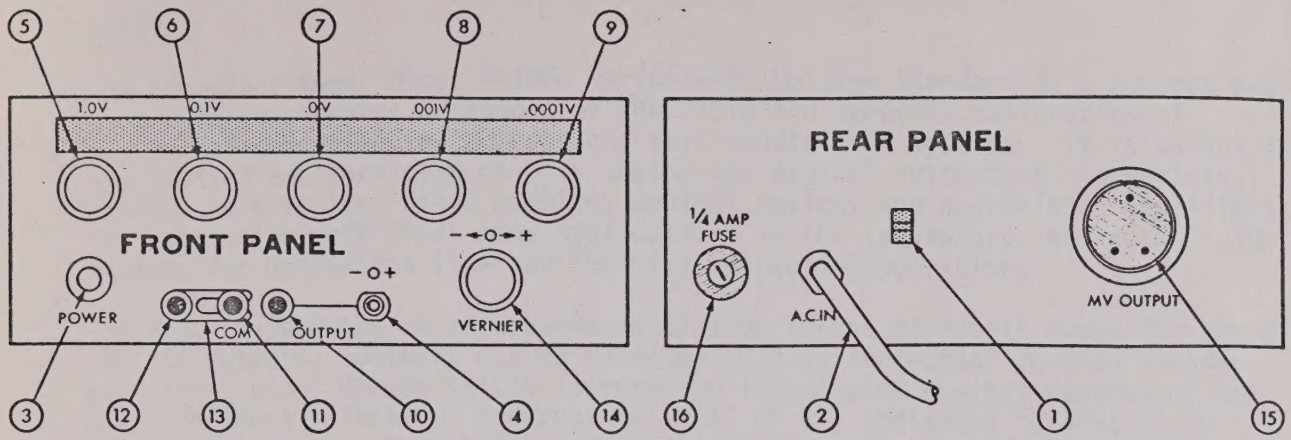


(1) Line Voltage Switch: makes connections in primary of input transformer for selected line voltage. Place in "up" position for 115v operation, and in "down" position for 230v operation.

(2) AC Power Cord: 3-wire power input cable. Connect only to source selected by line voltage switch. If adapter is used, connect green wire to line ground.

(3) Power Switch: pushbutton on-off switch that illuminates when in its "on" position and power is applied to the instrument.

(4) Polarity Switch: 3-position toggle type that selects a ± DC polarity for output jack. In its center "O" position the instrument is in a standby condition yet the load will not see the infinite impedance of an open circuit.

(5) First Decade Selector: 11-position rotary switch used to adjust output in 1 volt steps (or 10 mv steps*).

(6) Second Decade Selector: 11-position rotary switch used to adjust output in 1/10 volt steps (or 1 mv steps*).

(7) Third Decade Selector: 11-position rotary switch used to adjust output in 10 mv steps (or 100 μv steps*).

(8) Fourth Decade Selector: 11-position rotary switch used to adjust output in 1 mv steps (or 10 μv steps*).

(9) Fifth Decade Selector: 11-position rotary switch used to adjust output in 100 μv steps (or 1 μv steps*).

(10) Output Jack: red binding post for external load connection. DC output polarity is determined by position of polarity switch.

(11) Common Jack: black binding post for external load connection. DC output polarity is opposite from that selected for output jack.

(12) Ground Jack: white binding post for external connection to AC power ground.

(13) Shorting Link: metal jumper provided for convenient connection between common and ground jacks.

(14) Vernier: combination vernier control and push-pull switch. When this knob is pulled outward to its "on" position, the vernier control may be used to vary the output voltage ± 1 mv (or ± 10 μv*). The vernier knob must be pushed in to its "off" position for internally-calibrated output voltages.

(15) MV Output Connector: 3-wire Amphenol receptacle for external load connections to millivolt output source. All decade readouts must be divided by 100 when this output is used.

(16) Fuse Holder: screw-type connector for line fuse which protects entire instrument. Use only a type 3AG, 1/4 amp fuse in this application.

*Applies to rear-panel millivolt output only.

Figure 1. Model V-2000 Front and Rear Panel Description.

DESCRIPTION

GENERAL

The Esterline Angus Model V-2000 Variable DC Voltage Standard is a compact portable reference source designed for the rapid and accurate calibration of electrical-measuring instruments and data-acquisition systems. It is useful in the testing and servicing of both analog and digital voltmeters, converters, integrated circuits, range modules, control devices and operational amplifiers. This versatile unit finds many applications in the laboratory, and also in the factory for production line and incoming inspection operations.

The Model V-2000 has an adjustment resolution in the microvolt range for any of its DC outputs. Outputs may be selected by five individual 10-step decades. Each front-panel decade switch features an illuminated digital readout of the dial increment selected. Accuracy is .005% of the indicated readout (± 50 microvolts) and any 0-to-50MA load will have virtually no effect upon the output. In addition, a separate 1-MV vernier adjustment is provided on the front panel for precise external calibrations.

Besides the front panel output features, a connector is provided on the rear of the instrument to afford the operator a separate millivolt output range. This low-level source is also controlled by the five decade switches. In this mode of operation, however, decade readouts are divided by 100, and the sensitivity of the vernier adjustment is increased to a total range of ±10 microvolts.

SPECIFICATIONS

Output	
Voltage Range	0 to ±11.1110 V DC in five decades; ±1 MV DC vernier.
Attenuator	Built-in, 100:1, 100 ohms source impedance.
Current Capability	0 to 50 MA, short circuit proof.
External Load	Any.
Accuracy	0.005% of reading ±50 μV at 23°C. ±0.0002% per degree C.
Noise	0.001% of reading +50 μV.
Settling Time	<100 MS.
Warm-Up Time	<10 minutes.

Recommended Recalibration Interval	6 months.
Output Impedance	
DC	10 milliohms.
Dynamic	L ≤ 10 μH; R = 2 ohms.
Common Mode	±500 V Maximum.
Operating Temperature	0° to +60° C.
Storage Temperature	—25° to +85° C.
Power Requirements	117 or 243 V AC, 47 to 420 Hz, 10 watts maximum, R.F. filter included.
Dimensions	3½" high, 8½" wide, 12" deep. 19" rack mounting adapter available.

OPERATING INSTRUCTIONS

GENERAL

Although the operation of the Model V-2000 is simple and straight forward, attention to the following instructions and precautions will ensure optimum performance in the field. Operating controls, switches, connectors, etc. are identified and described in Figure 1.

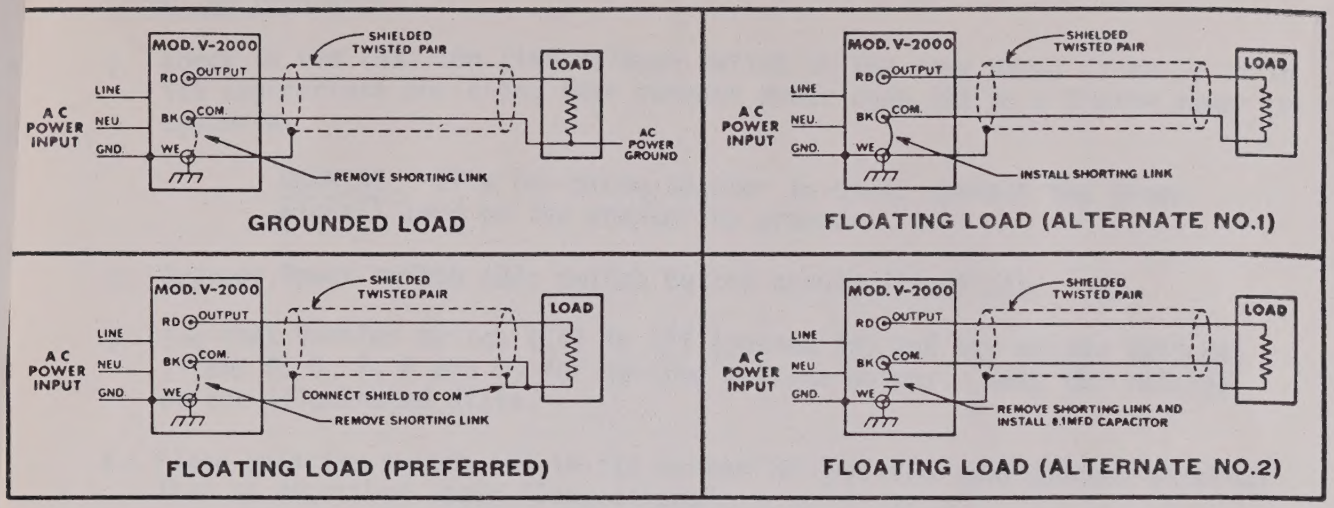


Figure 2. External Connection Diagrams.

CONNECTIONS

Front-panel connections for an external load are made to the universal-type binding posts (items 10, 11 and 12) shown in Figure 1. To help eliminate noise interference when large AC voltages are present between the case and the internal circuitry, a shorting link (item 13) is provided to connect "power line ground" to "common". When driving a load which is connected to power ground, the link should be removed to prevent a "ground loop". Recommended methods of connecting to both grounded and floating loads are shown in Figure 2. A shielded twisted pair is recommended for all load connections.

> CAUTION: Common-mode potentials must not exceed ±500 volts maximum. Always remove shorting link when operating in a common-mode condition.

Rear-panel connections to the MV OUTPUT connector should be made through the Amphenol plug supplied as a separate item with the instrument. Using a shielded twisted-pair cable, solder all connections to the pin plug as shown in Figure 3, and then assemble the connector with the set-screw supplied. The common and power-ground terminals of this connector are connected directly to respective terminals on the front panel. The shorting link and polarity switch may be used in the same manner as that for the front-panel output. External load connections illustrated in Figure 3 are also applicable for the MV OUTPUT.

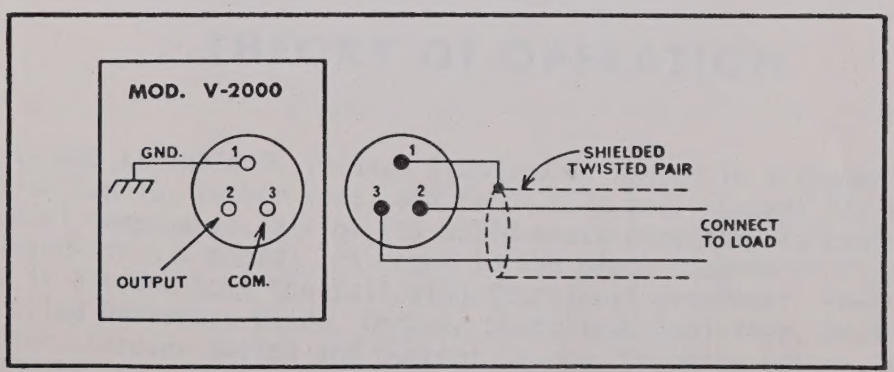


Figure 3. MV Output Connection Diagram.

OPERATING PROCEDURES

1. Check to see that the line voltage switch on the rear panel (item 1) is in its appropriate position; then connect power cord (2) to a 3-wire power receptacle.

   WARNING: If a two-prong adapter is used, connect the green pigtail lead on the adapter to ground.

2. Depress Power switch (3); switch button should illuminate.

3. See that Vernier switch (14) is off (pushed in) and set decade switches (items 5, 6, 7, 8 and 9) for desired voltage output. Read the voltage on the illuminated dials.

4. Place polarity switch (4) in its center "0" position and connect external load as described under "Connections".

5. Permit instrument to warm up; then place the polarity switch in the desired "+" or "-" position. The Model V-2000 is now adjusted to deliver the selected reference voltage to the load. A warm up time of 10 minutes is required.

Vernier Adjust: The front-panel Vernier (item 14) may be used in addition to the fifth decade switch to select an uncalibrated output voltage. To actuate the Vernier control, pull outward on the knob to its "on" position. The control may now be used as a finite voltage adjustment over the full range of the last decade dial. When using the MV OUTPUT, for example, each step of the last decade switch equals 1 microvolt for a total range of 10 microvolts; therefore the Vernier will control a ± output range of from 0-to-10 microvolts continuously variable. Any output obtained by adjustment of the Vernier control is, of course, uncalibrated with respect to the decade readout.

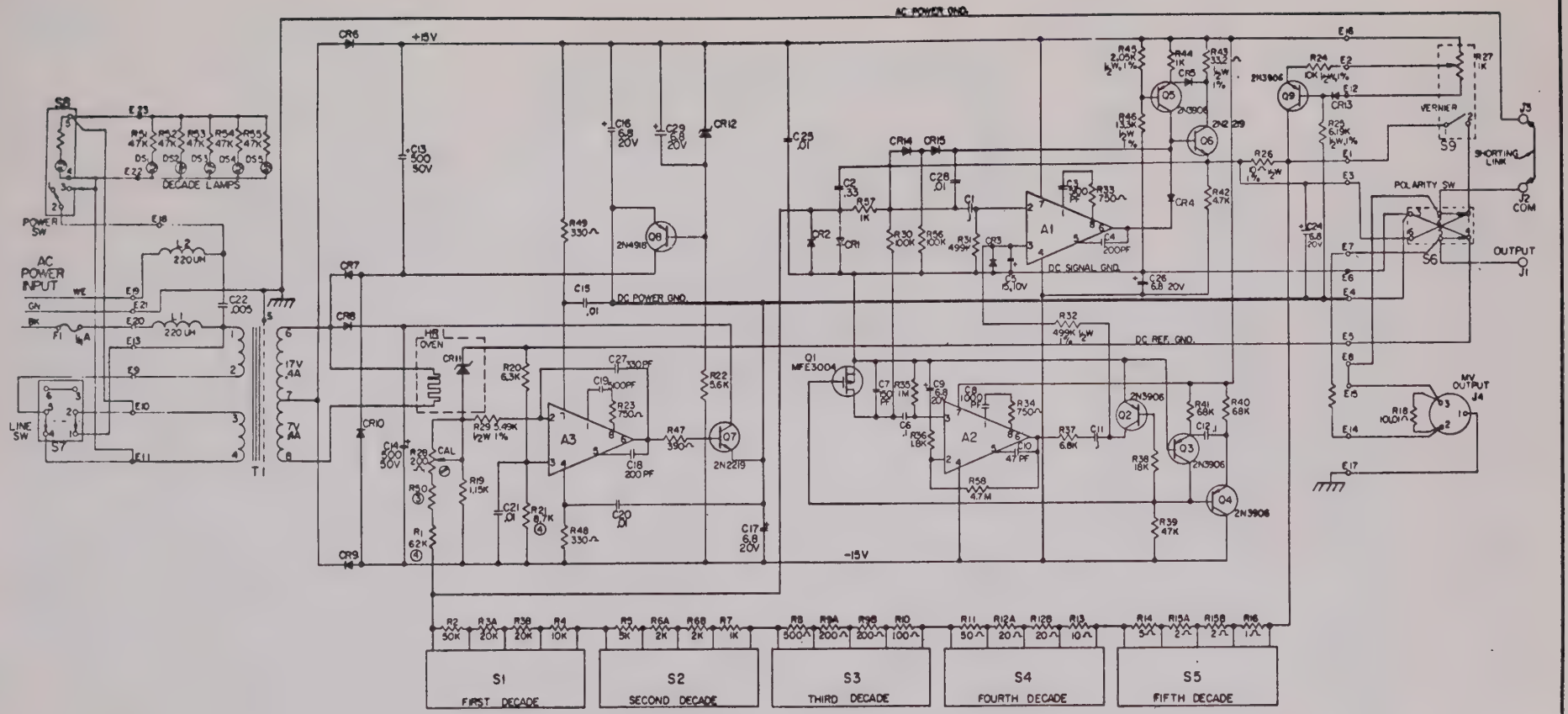
Output Impedance: The low output resistance of 10 milliohms is negligible in most applications, but may cause slight errors when heavily loaded. For example: a 10 V output supplying a 50 MA load would generate a voltage error of 50 MA times 10 milliohms. This equals 500μV or 0.005% of the output voltage. This error would appear directly at the output terminals of the unit and does not include any additional error introduced by high-resistance wiring to the load.

Output Current: The specified output current of 50 MA applies only when the DC Voltage Standard is used as a source. Current sinking capability is approximately 3 MA, but this may be increased by preloading the output.

THEORY OF OPERATION

GENERAL

The Model V-2000 Variable DC Voltage Standard is housed in a rugged metal case with carrying handle, rubber feet, and front tilt bar. Except for the front- and rear-panel components, all of its solid-state circuitry is contained on a single printed-circuit board. As shown in the block diagram of Figure 4, the instrument is divided into the following functional sections: Power Supply, Oven-Controlled Reference Diode, Chopper Stabilized Amplifier, Decade Feedback Selector, Vernier Switch and Current Source, Polarity Switch, and MV Divider (100:1).



NOTES:

(1) All fixed resistors are in ohms ±5%, ½ watt, unless otherwise specified.

(2) All capacitors are in microfarads unless otherwise specified.

(3) R50 is a ±1%, ½ watt, factory-selected resistor (806Ω, 1.2K or 1.6K).

(4) R1 and R21 are part of resistor set #A8-1047.

SYMBOLS:

Indicates case ground.

Indicates screwdriver adjustment.

Figure 5. Schematic of Model V-2000 Variable DC Voltage Standard.

CAUTION: Only a qualified person having access to the precision equipment specified should attempt recalibration of this instrument.

Set all decade switches to zero, polarity to "+", and push in the Vernier knob. Measure the output with the Galvanometer. Zero offset, for which there is no adjustment, should be less than 50μV. Disconnect the Galvanometer.

. Set the decade switches to +10.0000V and set the calibration standards to measure +10.0000V. Adjust potentiometer R28 until the output of the Model V-2000 agrees with the calibration standards.

. Set the decade switches for +1.0000V and set the calibration standards to measure +1.0000V. Check to see that the output of the unit agrees with the calibration standards to within ±100μV (±0.005%, ±50μV).

WARRANTY—The products sold hereunder are warranted as free from defects of materials and workmanship and in conformance with specifications. There are no other oral, statutory, or implied warranties. Seller's obligation hereunder shall be and is limited to servicing or replacing said product f.o.b. at its plant in Indianapolis, Indiana or at such other point as Seller may designate, or refunding the purchase price of any such product which proves to be defective in material or workmanship or which fails to conform to specifications therefor, provided that (1) written notice of such defect or failure is received by Seller from Purchaser within one year after the date of shipment of such products by Seller, and (2) such defects, in the opinion of Seller, shall not have arisen from improper use. The absence of such written notice of defect, or failure, or lack of conformance to specifications within the specified time shall constitute a waiver of any claim. Seller may, after receipt of notice, require purchaser to send said products, transportation prepaid, to Seller for its examination and inspection.

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Instruction Manual for Model 7000A Digital Multimeter

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5. The aforementioned provisions do not extend the original warranty period of any article which has been either repaired or replaced by Seller.

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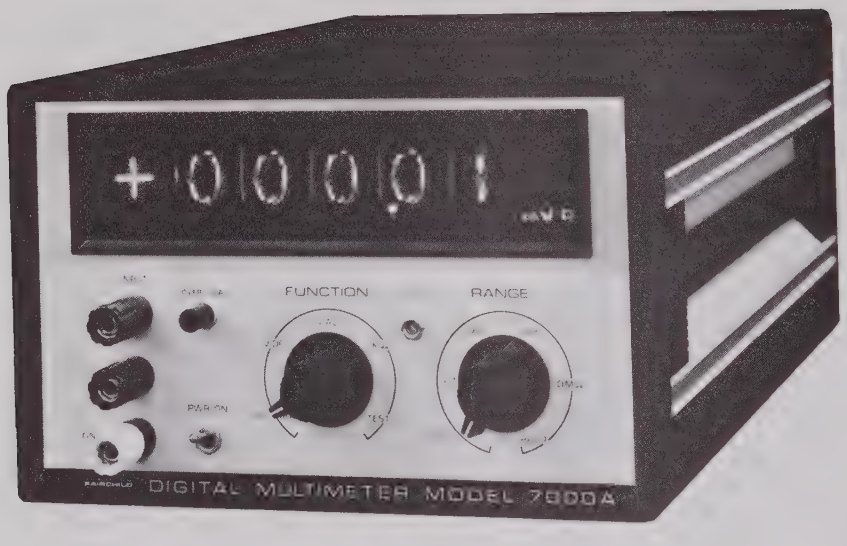


Figure 1-1. Model 7000A Digital Multimeter

Section I
General Information

INTRODUCTION

This manual provides operating and maintenance information for the Model 7000A Digital Multimeter. Section I is a general description of the instrument with a detailed list of optional equipment available. Sections II and III contain installation and operating information. Theory of operation is described in Section IV. Section V outlines maintenance and alignment procedures, and includes schematic diagrams of the unit. Section VI lists replacement parts.

GENERAL DESCRIPTION

The Model 7000A Digital Multimeter employs the dual slope integrating measurement technique to provide an instrument with excellent accuracy and long term stability characteristics. Solid-state electronics with the maximum use of integrated circuits gives the meter outstanding performance in a compact package.

The basic instrument is supplied as a DC voltmeter. Options, in the form of plug-in PC boards are available to extend the measurement capability to AC volts, DC current, and ohms. In addition, a DC preamplifier, autorange and binary-coded-decimal output boards may be ordered.

The measurement function is selected with the front panel FUNCTION switch. A visual indicator located on the right hand side of the readout panel shows the function selected. DC voltage measurements are given in direct readout from 0.0001 to 1000.0 volts, DC mV from 000.01 to 100.00 mV, DC current from 0.0001 to 1000.0 mA, AC volts from 0.0001 to 750 volts rms, and resistance from 0.0001 to 10000 kΩ. Polarity indication is automatic where applicable.

Manual range selection is a standard feature with all options and is controlled from the front panel. Autoranging is optional and is provided in the form of a single plug-in card.

The meter has a 20% over-ranging capability on all measurement functions, providing a full scale readout of 12000. When the input signal exceeds the over-ranging limit, a red OVERLOAD indicator on the front panel flashes on and off. When auto-ranging is fitted, the range is automatically increased to the next higher range when the readout exceeds 12000. The instrument will downrange if the level of the input signals is less than 00980.

The measurement accuracy achieved by the Model 7000A is attributed directly to the dual slope integration technique. Dual slope integration is a two-step process. In the first step, the unknown input is fed through an operational amplifier to an integrating capacitor. The integrator output is an increasing voltage with a slope proportional to the input. Integration time is controlled by counting 10,000 pulses from a clock oscillator. In the second step, the integrator input is switched to an internal reference current, and the integrator output is driven back to zero. The slope of the decreasing voltage is proportional to the reference current, and the time required to return the voltage to zero is directly proportional to the unknown input. This time is measured by counting pulses from the same clock oscillator used in the first step. The count is displayed as the digital readout.

Since the same integrating components and clock oscillator are used in both steps, any shift in value of components, due to temperature changes or aging, etc., become self-cancelling. Because the second step is a direct comparison to the internal reference current, the instrument has excellent long-term stability.

OPTIONS

Accurate measurement of DC voltage is performed with the basic version of the Model 7000A. The addition of optional plug-in boards permits the instrument to measure DC current, AC voltage and ohms. Auto-ranging and BCD readout options are also available. Any or all of these options may be added to the Model 7000A, depending on the requirements of the user. Installation of options is discussed in Section II of this manual. Each option is briefly described as follows:

OPTION 01 – Auto-Range. Provides auto-ranging circuitry. The logic circuits in the plug-in indicate an up-range pulse when the readout exceeds 12000 and a down-range pulse when the readout falls to 00980 or lower.

OPTION 02 – AC Volts. Utilizes an averaging technique giving a readout that is a true representation of the rms value of a sine wave input. Readout range is from 0.0001 to 750.0 V rms, 50 Hz to 100 kHz. The optional plug-in contains circuitry that converts the unknown AC input signal to an equivalent DC voltage that is then measured by the DC measuring portion of the instrument. **OPTION 06** is similarly designed and has a readout range of 0.0001 to 750.0 V rms, 50 Hz to 20 kHz.

OPTION 03 – Resistance. Utilizes an ohms converter to give resistance measurements from 0.0001 kΩ to 10 MΩ. Circuitry within the plug-in board assembly directs a calibrated current through the unknown resistance, and the resulting DC voltage drop is measured by the DC voltage section of the instrument.

OPTION 04 – DC Current. Allows measurement of DC current from 0.0001 mA to 1000.0 mA. The plug-in contains a number of current shunts. The current to be measured is directed through a calibrated resistance, and the resulting DC voltage is measured by the DC measurement circuit.

OPTION 05 – BCD Output. This provides a 1-2-4-8 binary-coded-decimal output of the readout plus the necessary operating signals to drive external printers, data logging equipment, etc.

OPTION 07 – A plug-in preamplifier board that gives a 100 mV full scale DC readout. Option 07 shares certain circuitry with Option 04, therefore only one function or the other can be selected at one time.

SPECIFICATIONS

Table 1-1 contains complete electrical specifications for the Model 7000A and all options.

DIMENSIONS AND WEIGHT

Figure 1-2 is an outline drawing of the Model 7000A showing principal dimensions in inches and millimeters. Approximate weight of the basic instrument is 12 lbs/5.5 kilos and 13 lbs/6.8 kilos with all options installed.

Table 1-1. Specifications, Model 7000A

DC VOLTS	
DC Ranges: (Manual and Auto):	Four Ranges: 1.0000 V full scale + 20% over range 10.000 V full scale + 20% over range 100.00 V full scale + 20% over range 1000.0 V full scale
Accuracy:	±(0.01% of reading + 0.01% of full scale)
Resolution:	100 μV (1 V range)
Integration Time:	50 msec
Measurement Rate:	5 per sec
Step Response Time:	600 msec to read within specified accuracy of final value without a range change.
Input Impedance:	1 V. . . . > 1 kMΩ 10 V. . . . > 1 kMΩ 100 V. . . . ≅ 10 MΩ 1000 V. . . . ≅ 10 MΩ
Temperature Coefficient:	1 V. . ±(.002% of reading +0.0008% of full scale)/°C 10 V. . ±(.002% of reading +0.0008% of full scale)/°C 100 V. . ±(.006% of reading +0.0008% of full scale)/°C 1000 V. . ±(.006% of reading +0.0008% of full scale)/°C
Voltage Coefficient:	±0.0005%/V
Temperature Range:	+5°C to +45°C
Normal Mode Rejection:	>30 dB at 60 Hz >40 dB at 120 Hz >50 dB at 400 Hz
Overload Protection:	1.2 kV maximum on any range with no damage.
AUTO RANGE (Option 01)	
Up Range Point:	1.2000 -0 + 9 digits 12.000 -0 + 9 digits 120.00 -0 + 9 digits
Down Range Point:	00.980 +0 -9 digits 009.80 +0 -9 digits 0098.0 +0 -9 digits

Table 1-1. Specifications, Model 7000A (Continued)

AUTO RANGE (Option 01) Continued

Range Response Time:

	Typical	Worse Case
V DC	250 msec	1.2 sec
V AC	3 sec	20 sec
kΩ	250 msec	20 sec
mA	250 msec	1.2 sec

AC VOLTS (Option 02)

1.0000 V full scale + 20% over range
10.000 V full scale + 20% over range
100.00 V full scale + 20% over range
1000.0 V full scale (750 V max.)

Accuracy:

50 Hz to 10 kHz . . ±(0.1% of reading +0.02% of full scale)
10 kHz to 30 kHz . . ±(0.25% of reading +0.05% of full scale)
30 kHz to 100 kHz . ±(1.0% of reading +0.2% of full scale)

Input Impedance: 1 MΩ shunted by 50 pF

Temperature Coefficient:

50 Hz to 10 kHz . . ±(0.005% of reading +0.0015% of full scale)/°C
10 kHz to 30 kHz . . ±(0.01% of reading +0.003% of full scale)/°C
30 kHz to 100 kHz . ±(0.05% of reading +0.01% of full scale)/°C

Maximum Input Voltage:

50 Hz to 10 kHz . . 750 V
10 kHz to 30 kHz . . 500 V
30 kHz to 100 kHz . 350 V

Voltage Coefficient: ±0.0005%/V

Integration Time: 50 msec

Measurement Rate: 1 per sec

Full Scale Step Response Time: 10 sec

Overload Protection: 750 V AC

OHMS (Option 03)

Ranges:

1.0000 kΩ full scale + 20% over range
10.000 kΩ full scale + 20% over range
100.00 kΩ full scale + 20% over range
1000.0 kΩ full scale + 20% over range
10000 kΩ full scale

Table 1-1. Specifications, Model 7000A (Continued)

OHMS (Option 03) Continued

Accuracy:	1, 10 and 100 kΩ . . ±(0.05% of reading +0.02% of full scale) 1000 kΩ . . . . . ±(0.10% of reading +.03% of full scale) 10 MΩ . . . . . ±(0.2% of reading +.05% of full scale)
Resolution:	0.1 Ω (1 kΩ range)
Integration Time:	50 msec
Measurement Rate:	5 per sec
Step Response Time:	1, 10 and 100 kΩ . . 1 sec 1000 kΩ . . . . . 5 sec 10 MΩ . . . . . 20 sec
Overload Protection:	Maximum of 100 V may be applied without damage.
Temperature Coefficient:	1 to 1000 kΩ . . ±(0.005% of reading ±0.0015% of full scale)/°C 10 MΩ . . . . . ±(0.005% of reading ±0.005% of full scale)/°C
Measurement Current:	1 kΩ to 10 kΩ range . . 1 mA 100 kΩ range . . . . .100 μA 1 MΩ . . . . . 1.0 μA 10 MΩ . . . . . 1.0 μA

DC CURRENT (Option 04)

Ranges:	1.0000 mA full scale + 20% over range 10.000 mA full scale + 20% over range 100.00 mA full scale + 20% over range 1000.0 mA full scale
Accuracy:	±(0.13% of reading +0.02% of full scale)
Resolution:	100 nA (1 mA range)
Integration Time:	50 msec
Measurement Rage:	5 per sec
Step Response Time:	600 msec
Temperature Coefficient:	±(0.003% of reading +0.0008% of full scale)/°C
Overload Protection:	Maximum of 2 A may be applied safely to any range without damage.

Table 1-1. Specifications, Model 7000A (Continued)

DC CURRENT (Option 04) Continued	
Input Impedance:	1 mA . . . 1 kΩ 10 mA . . . 100 Ω 100 mA . . . 10 Ω 1000 mA . . . 1 Ω
BCD OUTPUT CODING (Option 05)	
1-2-4-8 Positive True Logic:	Numbers, Decimal Point, Polarity and Function indicated by a "0" state of +0.5 V maximum and a "1" state of +20 V minimum. Source resistance approximately 100 kΩ.
AC VOLTS (Option 06)	
Ranges:	1.0000 V full scale + 20% over range 10.000 V full scale + 20% over range 100.00 V full scale + 20% over range 1000.0 V full scale (750 V max.)
Accuracy:	50 Hz to 10 kHz . . ±(0.1% of reading +0.02% of full scale) 10 kHz to 20 kHz . . ±(0.25% of reading +0.05% of full scale)
Input Impedance:	1 MΩ shunt by 50 pF
Temperature Coefficient:	50 Hz to 10 kHz . . ±(0.005% of reading +0.0015% of full scale)/°C 10 kHz to 20 kHz . . ±(0.01% of reading +0.003% of full scale)/°C
Maximum Input Voltage:	50 Hz to 10 kHz . . 750 V 10 kHz to 20 kHz . . 500 V
Voltage Coefficient:	±0.0005%/V
Integration Time:	50 msec
Measurement Rate:	1 per sec
Full Scale Step Response Time:	10 sec
Overload Protection:	750 V AC

Table 1-1. Specifications, Model 7000A (Continued)

PREAMPLIFIER (Option 07)

Specification at 23°C (Unless otherwise noted)

DC Ranges (Manual Only):	100 mV full scale + 20% over range
Accuracy:	±(0.01% of reading ±0.02% of full scale)
Resolution:	10 μV
Input Impedance:	>100 MΩ
Input Offset Current:	<100 pA
Integration Time:	50 msec
Measurement Rate:	200 msec
Step Response Time:	1 sec (to read within specified accuracy of final value).
Temperature Coefficient:	±(0.003% of reading ±0.001% of full scale)/°C the mV zero pot must be adjusted at the new temperature
Over Voltage Protection:	300 V DC or 210 V AC

GENERAL

Input Power:	115 V AC or 220 V AC ± 10% 50 Hz to 400 Hz, 20 W
Isolation:	500 V to case and power line ground.
Polarity Selection:	Automatic
Overload Indication:	Flashing red light.
Readout:	Measurement function, four digits of data (with decimal point) and polarity plus an over range digit displayed by 6 long life, side viewing, neon glow numerical display tubes and a function indicator lamp.
Dimensions:	12" deep x 5 1/4" high x 8 3/8" wide (31 x 13 x 21 cm)
Weight:	12 lb (5.5 kg) 15 lb (6.8 kg) maximum with all options.

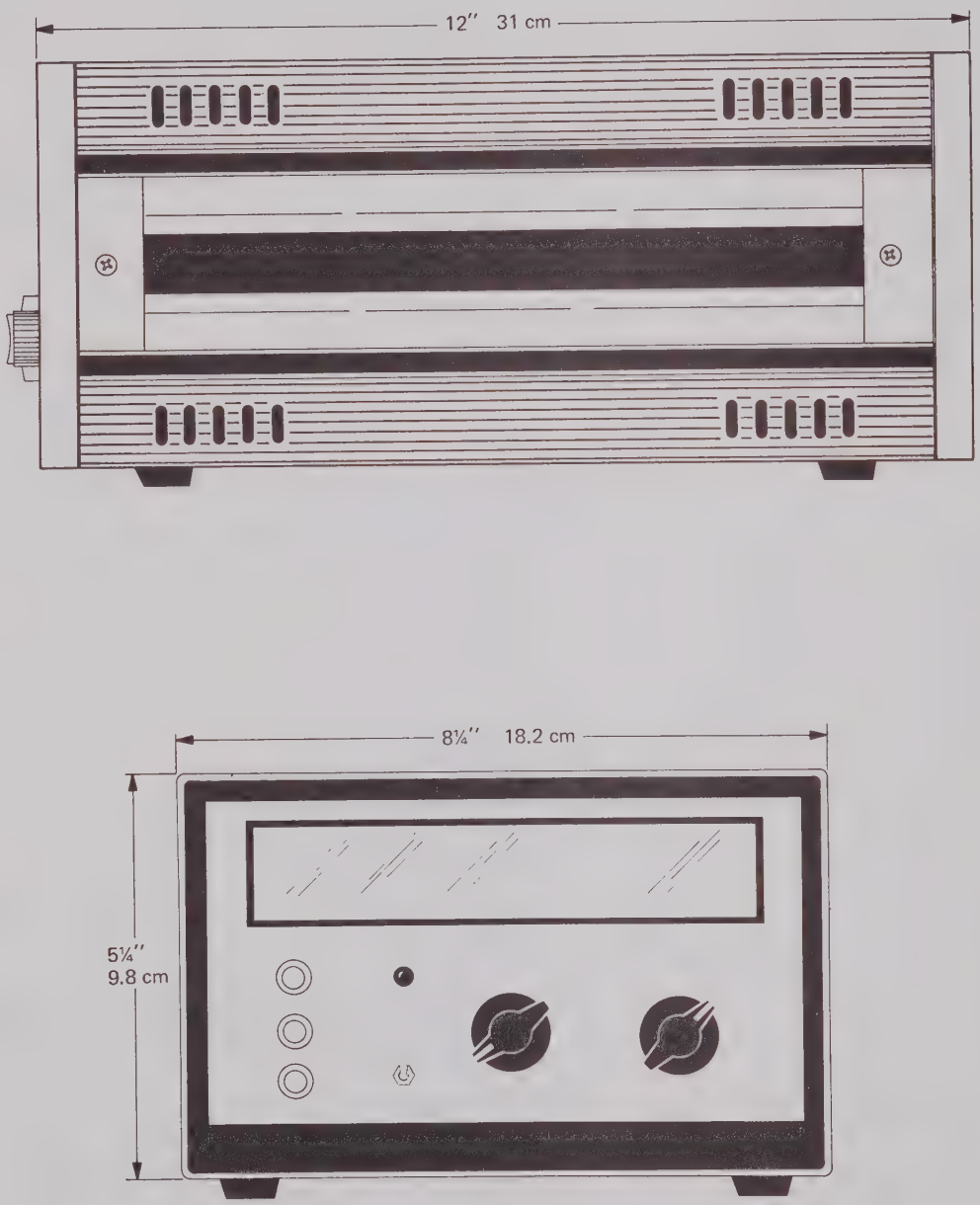


Figure 1-2. Overall Dimensions, Model 7000A

Section II
Installation

INTRODUCTION

This section outlines procedures for inspection and initial installation of the Model 7000A and options. Reshipment instructions are included in case the instrument must be returned to Fairchild Instrumentation.

UNPACKING AND INSPECTION

Before accepting the instrument from the shipper, the packaged instrument should be inspected for external damage. Any sign of external damage must be noted by both customer and shipper, and should be called to the attention of the insurance investigator.

As soon as the equipment is unpacked, inspect the instrument for damage in shipment; check for scratches or dents and damaged knobs or connectors. Remove top cover plate and make sure that all plug-in boards are seated firmly in their sockets. If damage is noted, do not use the instrument unless instructed by the insuring agency.

POWER REQUIREMENTS

The Model 7000A is designed to operate from a 115/230 V, 50 to 400 Hz power source. Do not connect the instrument to a power source with incorrect voltage or inadequate current rating. The 115/220 V switch (located on the rear panel of the instrument directly above the power cord plug) should be set to the appropriate position, i.e., 115 for 115 V operation, 230 for 230 V operation.

The Model 7000A is equipped with a three-conductor power cable that grounds the instrument when the connector is plugged into an appropriate receptacle. To preserve this safety feature when operating with a two-contact outlet, use an adapter and connect the pigtail on the adapter to a suitable ground.

OPERATIONAL CHECK

The following preliminary operational check may be used to ensure that all components and circuits are in operating condition when the instrument is first operated. Refer to figure 3-1 and 3-2 for location of operating controls. The procedure provides a quick check for proper functioning, but does not check specifications completely. Refer to page 5-1 for description of a complete performance check.

a. Check that 115/230 V switch is in correct position and then connect instrument to AC power source. Set PWR ON switch to ON. Check that readout panel lights up.

b. Set FUNCTION switch to TEST and RANGE switch to 1 V.

c. Check that readout indicates 0.1000 ± 1 digit after a short warm-up period.

RESHIPMENT

When an instrument is damaged in shipment, do not return it to Fairchild Instrumentation without specific instructions from the insuring agency. Neither the customer nor Fairchild is required to assume responsibility for reshipment.

When a damaged instrument is to be returned to the factory for service or repair, contact your nearest Fairchild Instrumentation engineering representative for written permission to ship, shipping instructions and a shipping form.

INSTALLATION OF OPTIONS

The addition of each of the options available for the Model 7000A with the exception of DC mA Option 04, BCD Option 05, and DC mV Option 07, requires the simple insertion of PC cards into the appropriate connectors on the instrument Mother Board. To install options, proceed as follows:

a. Remove all signal inputs to instrument and disconnect it from AC power source.

b. Remove top cover to expose PC plug-in connections on mother board A13. See figure 5-5.

c. Insert option into appropriate connector and press firmly into place.

Option	Connector
01—Auto-Range	XA4
02—AC Volts	XA9
03—Resistance	XA10
06—AC Volts	XA9

d. Check readout accuracy following procedures given in Section V of the manual.

INSTALLATION OF DC MA OPTION 04

To install Option 04, carry out the following steps:

a. Remove all signal inputs to instrument and disconnect it from AC power source.

b. Remove top cover to expose mother board and PC plug-in connectors.

c. Insert Option 04 Assembly A13 into connector XA14.

d. Change wiring on switches S3 and S4 as shown in figure 2-1. Remove unit readout shade and replace with shade supplied. Replace cover. Perform DC current readout accuracy check given in Section V of this manual.

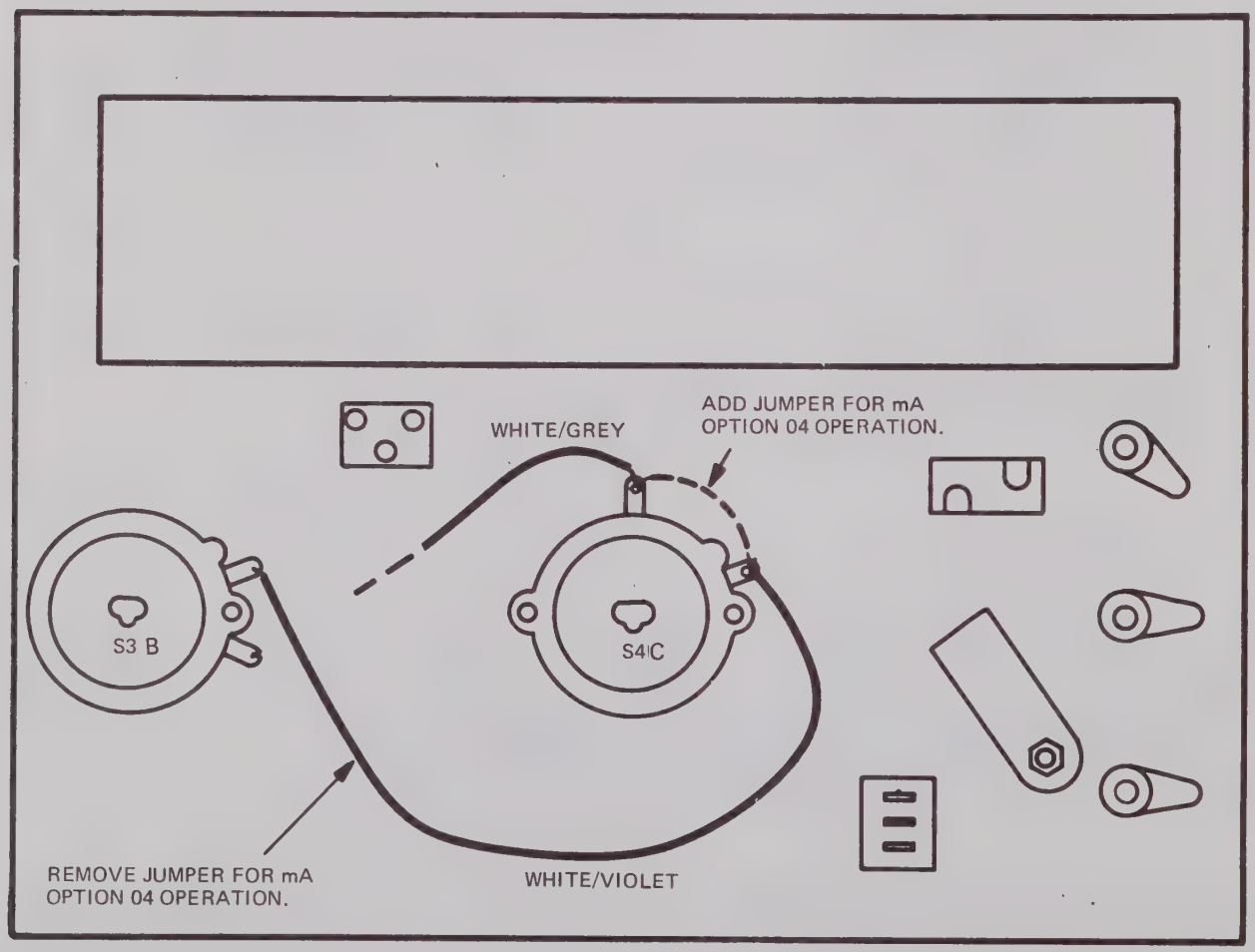


Figure 2-1. Wiring Change for mA (Option 04) Operation

INSTALLATION OF BCD OPTION 05

To install Option 05, carry out the following steps:

a. Remove all signal inputs to instrument and disconnect it from AC power source.

b. Remove top and bottom covers from instrument.

c. Remove cover plate from "Accessories" slot on real panel. Remove plug-in boards A4 and A5.

d. Consult operating instructions for Option 05 given in next paragraph and program board for desired mode of operation. The signals supplied by Option 05 are detailed in table 2-1.

e. From top of instrument, feed Option 05 connector J1 through hole in mother board A13. See figure 2-2.

f. Insert Option 05 board into mother board connector marked BCD A3.

g. Turn Model 7000A on its side and dress cable as shown in figure 2-2.

h. Feed Option 05 connector J1 through ACCESSORIES slot on rear panel and mount on panel using hardware supplied.

i. Replace plug-in boards A4 and A5 and replace top and bottom covers on instrument.

OPERATION–BCD OPTION 05

BCD Option 05 serves as a signal conditioner for the Fairchild CμL959 integrated circuit storage elements, changing their outputs to a level suitable for printer application. Option 05 also performs the necessary logic functions required for proper operation of the printer.

Cycle Mode*

The sampling rate of the cycle mode is determined by the Model 7000A measurement time and the printer readout time. With a full scale input, measurement time is approximately 120 msec. The printer will have a cycle time of approximately 200 msec. The maximum printout rate that can be expected with a full scale input is 3 to 4 per second.

To program cycle operation:

a. Connect a jumper between CYCLE contacts on Option 05 plug-in board.

b. Short PRINT terminal J1-21 to ground (Terminal J1-46). Opening this connection will halt the printer.

Remote Print*

To obtain remote control of print command:

a. Remove jumpers from Option 05 board CYCLE and HOLD terminals.

b. Provide closure for PRINT terminal J1-21 to ground (J1-46).

Hold Mode*

To obtain a hold mode of operation:

a. Connect a jumper between HOLD terminal on Option 05 board.

b. Provide a closure for PRINT terminal J1-21 to ground (J1-46). This initiates one print cycle after which the DVM readout will be held as long as J1-21 is grounded.

*If no external inhibit is supplied, the signal from J1-21 (print common) must be applied to J1-22 (INHIBIT).

INSTALLATION OF DC MV OPTION 07

To install Option 07 in the Model 7000A proceed as follows:

a. Remove all signal inputs to the instrument and disconnect it from the AC power line.

b. Remove top cover to expose mother board and PC plug-in connectors.

c. Remove jumper Board Assembly A11.

d. Insert Option 07 assembly A15 into connector XA14. Press firmly into place.

e. Replace cover on instrument and reconnect to AC power line. Carry out accuracy check given on page 5-2. If necessary, perform alignment procedure on figure 5-4.

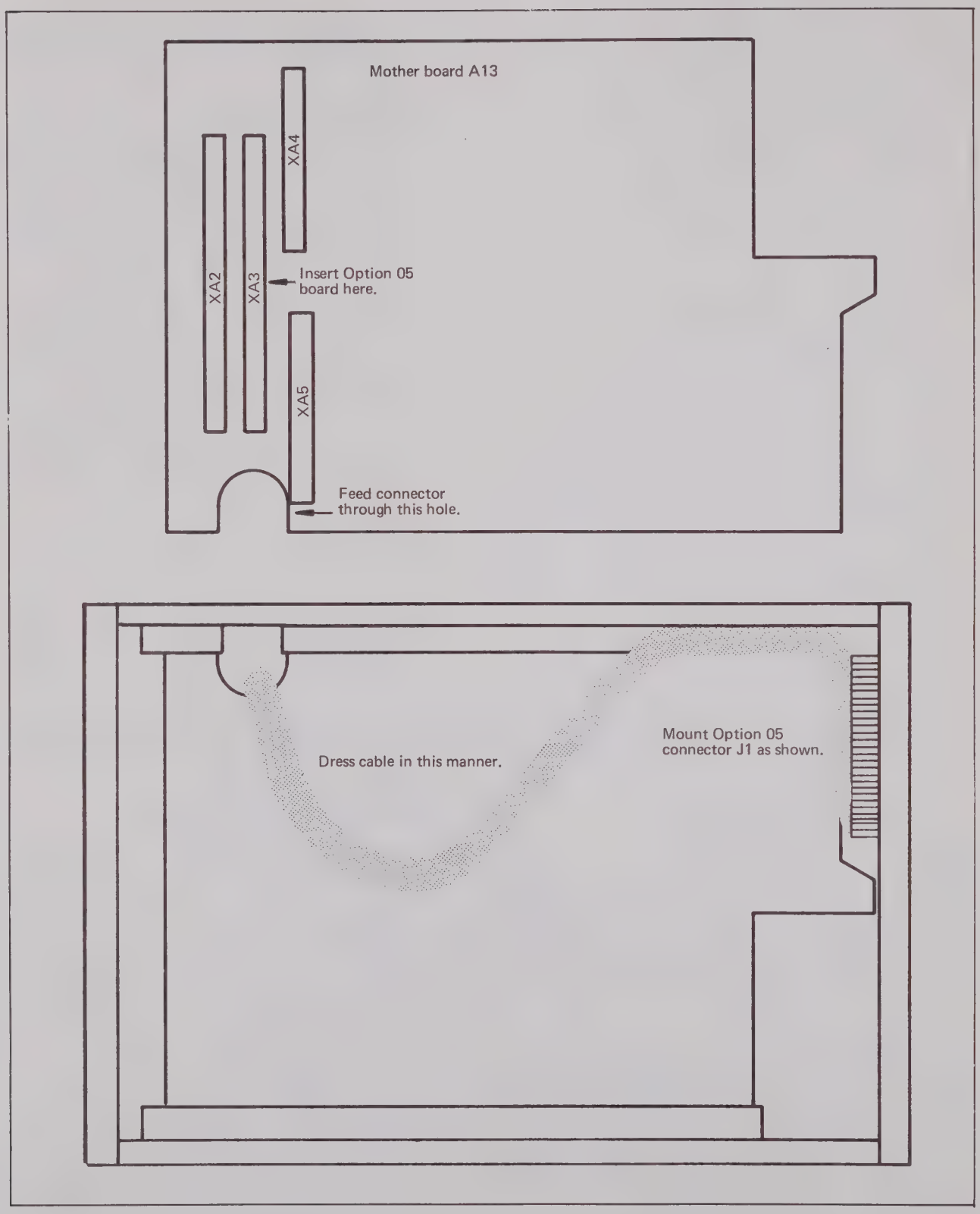


Figure 2-2. Installation Instructions, BCD Option 05

Table 2-1. Input and Output Signals, BCD Option 05

OUTPUT	CODE	J1 PIN DESIG.	REMARKS
FUNCTION	1 2 4 8	17 18 42 43	LEVELS: "0" = 0 V, ± 1 V; "1" = +25 V, ± 5 V OUTPUT IMPEDANCE: A transistor switch with the collector connected to 25 V through a 100 kΩ resistor and a 10 kΩ isolation resistor in series with the output for protection. DECODE:
OVERLOAD	1 2 4 8	15 16 40 41	
POLARITY	1 2 4 8	13 14 38 39	
OVER-RANGE DIGIT (0.1)	1 2 4 8	11 12 36 37	
1000's	1 2 4 8	9 10 34 35	
100's	1 2 4 8	7 8 32 33	
10's	1 2 4 8	5 6 30 31	
UNITS	1 2 4 8	3 4 28 29	
DECIMAL	1 2 4 8	1 2 26 27	
PRINT COMMAND		23	A pulse step from 0 to +18 V (22 V max, 15 V min), 100 μsec ± 50 μsec wide, rise time > 1 V per μsec. Output impedance is 100 Ω.
INHIBIT		22	Inhibit sig. must be pos. pulse from printer to Opt. 05. A min. level of 15 V is reqd. Input impedance is > 27 kΩ. See footnote on page 2-3.
+ REF - REF		25 24	Reference levels (no load conditions): High (+) 17 V ± 3 V. Source impedance 4.7 kΩ ± 20% Low (–) 5 V ± 2 V. Source impedance 3.9 kΩ ± 20%.

DECODE:

			8	4	2	1
FUNCTION	Test	=	0	0	0	0
	DC	=	0	0	0	1
	kΩ	=	0	0	1	0
	AC	=	0	1	0	0
	mA	=	1	0	0	0
OVERLOAD	Overload	=	0	0	0	0
	No Overload	=	0	0	1	0
POLARITY	Negative (–)	=	1	0	1	1
	Positive (+)	=	1	0	1	0
	No Polarity	=	1	0	1	0
DIGITS	0	=	0	0	0	0
	1	=	0	0	0	1
	2	=	0	0	1	0
	3	=	0	0	1	1
	4	=	0	1	0	0
	5	=	0	1	0	1
	6	=	0	1	1	0
	7	=	0	1	1	1
	8	=	1	0	0	0
	9	=	1	0	0	1
DECIMAL	xxxxx	=	0	0	0	0
	xxxx.x	=	0	0	0	1
	xxx.xx	=	0	0	1	0
	xx.xxx	=	0	0	1	1
	x.xxxx	=	0	1	0	0

NOTES

Section III
Operation

INTRODUCTION

The Model 7000A Digital Multimeter will measure DC voltage, and, with the inclusion of optional plug-in circuit boards, AC voltage, DC millivolts, DC current, and resistance. Ranging is manual, or automatic with the optional auto-ranging plug-in board. The full potential of this instrument can be realized only when the user has gained full appreciation of its operating principles and control functions. This section defines the functions of all controls and provides instructions to be observed when making measurements.

OPERATING CONTROLS

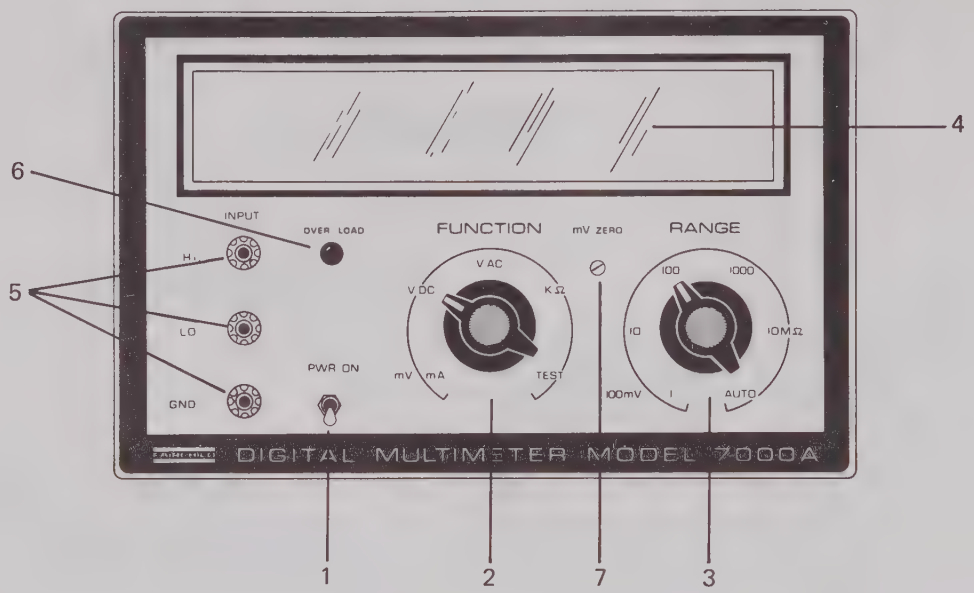
Figure 3-1 is a description of the front panel operating controls and figure 3-2 depicts the rear panel controls and connectors.

OPERATING INSTRUCTIONS

NOTE

Before attempting measurements with the instrument, it is recommended that its operation be checked with the SELF CHECK procedure outlined in figure 3-3.

Figures 3-4 through 3-12 outline instructions for making measurements with the Model 7000A. Each figure discusses a particular mode of operation. The number or numbers associated with each control indicate the step in which the control is used.



1. PWR ON switch applies primary power to instrument.

2. FUNCTION switch:

   a. Connects instrument self-check feature into circuit when switched to TEST. Readout should be 0.1000 when RANGE switch is set to 1.

   b. Permits measurement of DC volts when switched to V DC.

   c. Permits measurement of resistance when switched to KΩ (an optional feature).

   d. Permits measurement of AC volts when switched to V AC (an optional feature).

   e. Permits measurement of DC current or millivolts when switched to mV/mA (optional features).

3. RANGE Control:

   a. Selects automatic ranging when switched to AUTO (an optional feature).

   b. Selects instrument readout range:

   1 . . . . . x.xxxx
   100 mV . . xxx.xx (Option 07)
   10 . . . . xx.xxx
   100 . . . . xxx.xx
   1000 . . . xxxx.x
   10 MΩ . . . xxxx (KΩ mode only)

4. READOUT Panel presents:

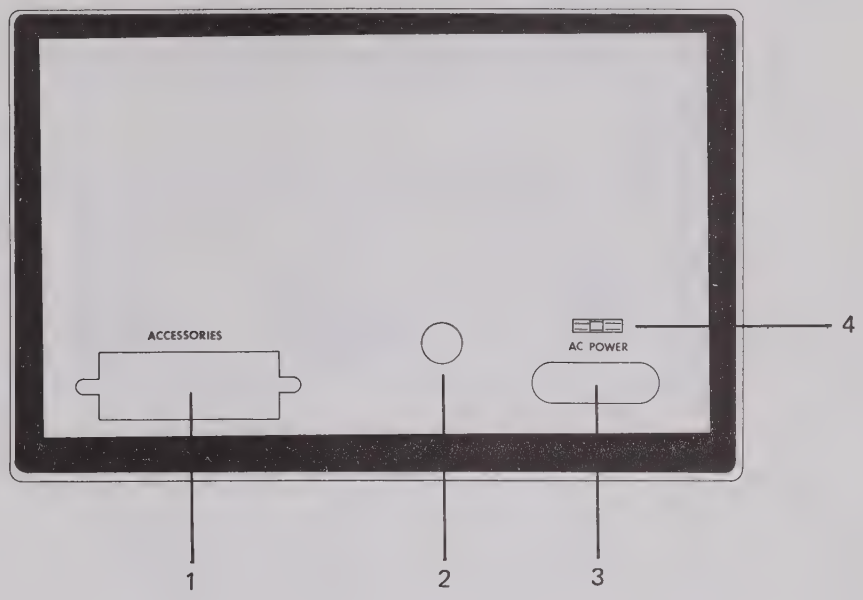
   Five digits of data (including one overrange digit), decimal point, function, and polarity.

5. HI, LO, and GND terminals are input connectors for floating or grounded sources.

6. OVERLOAD indicator flashes when amplitude of input signal exceeds range setting.

7. mV ZERO adjustment compensates for preamplifier drift due to temperature change.

Figure 3-1. Front Panel Description



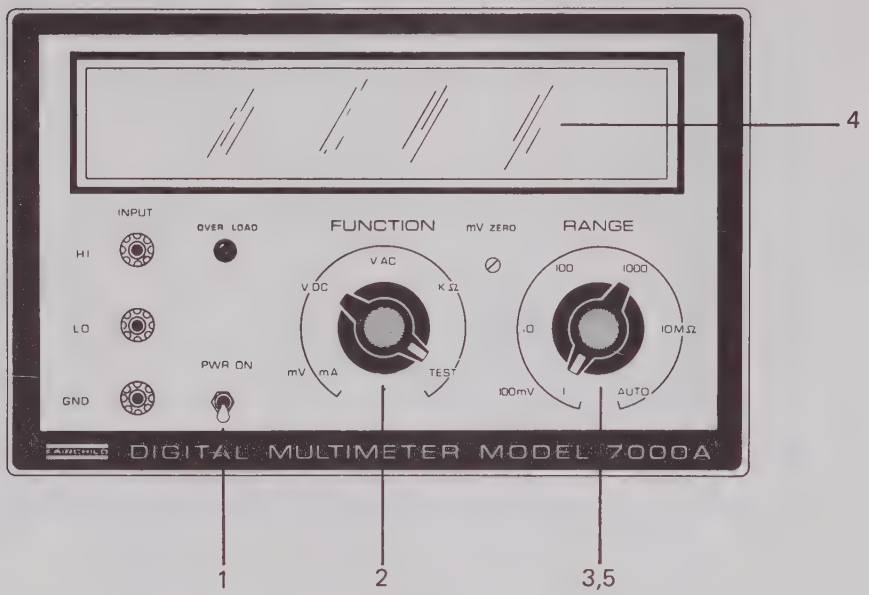
1. 50-pin Amphenol connector provides a 1-2-4-8 binary-coded-decimal output for use with external data logging equipment (an optional feature).

2. FUSE provides overload protection. Replacement value is ½ ampere, slow-blow for 115 V AC operation; ¼ ampere, slow-blow for 230 V AC.

3. 115 V/230 V switch permits selection of power input from either 115 V AC or 230 V AC source.

4. Input power connector for three wire power cable. Input can be 115 V/230 V, 50 to 400 Hz.

Figure 3-2. Rear Panel Description



1. Connect instrument to AC power source. Set PWR ON switch to ON.

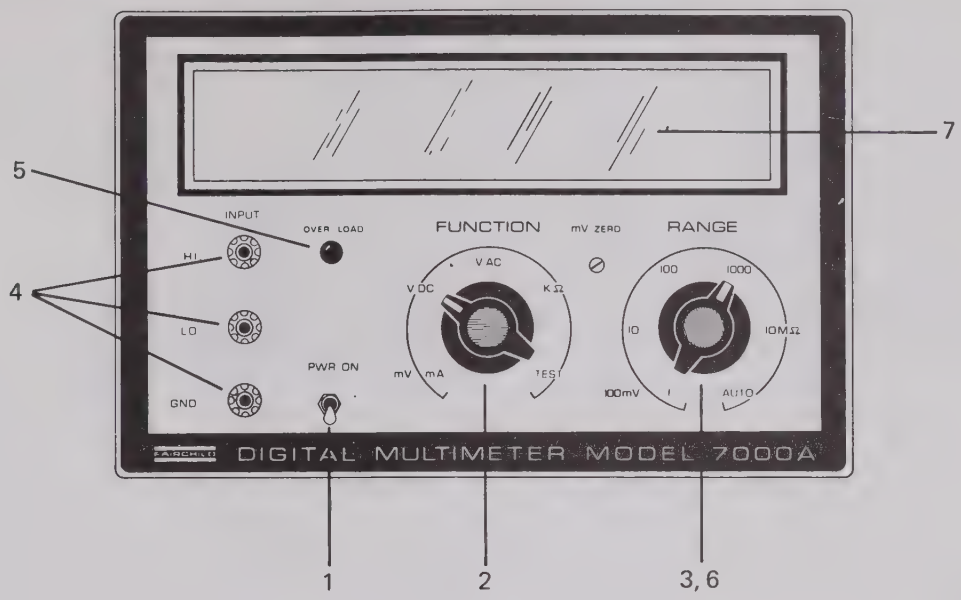
2. Set FUNCTION switch to TEST.

3. Set RANGE switch to 1.

4. Check that readout is 0.1000 ± 1 digit.

5. Set RANGE switch to 10, 100 and 1000. Readout should be 01.000, 010.00 and 0100.0 respectively.

Figure 3-3. Instrument Self Check



1. Connect instrument to AC power source. Set PWR ON switch to ON.
2. Set FUNCTION switch to V DC.
3. Set RANGE switch to 1000.
4. Connect HI, LO, and GND terminals to unknown DC voltage source. Voltage amplitude must be within 0 to 1000 V DC range.
5. If OVERLOAD indicator is flashing, input voltage is beyond measurement range of instrument. Disconnect instrument from voltage source.
6. Progressively select lower RANGE settings until correct range is reached.
7. Read voltage on display. Decimal point is correctly positioned. Measurement unit (V DC) and polarity are displayed.

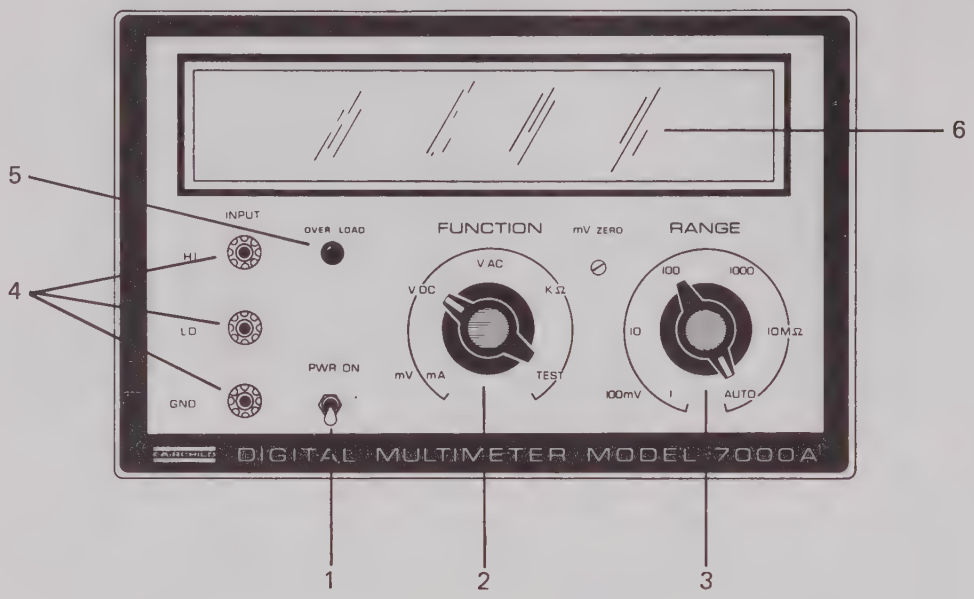
NOTE

The terminals must be used correctly to reduce ground loop currents to a minimum and achieve best measurement accuracy. When measuring a low level, high impedance source with its own ground, connect GND terminal to the source ground and the HI and LO terminals to the high and low outputs of the source. For all other measurements connect the GND and LO terminal to one measurement point and the HI terminal to the other.

CAUTION

THE MEASURING CIRCUIT IS FLOATED FROM THE CHASSIS GROUND OF THE INSTRUMENT. THE POTENTIAL APPLIED BETWEEN LO AND GND MUST NOT EXCEED 500 V OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Figure 3-4. DC Voltage Measurement, Manual Ranging



1. Connect instrument to AC power source. Set PWR ON switch to ON.
2. Set FUNCTION switch to V DC.
3. Set RANGE switch to AUTO.
4. Connect HI, LO, and GND terminals to unknown DC voltage source. Voltage amplitude must be within 0 to 1000 V DC range.

NOTE

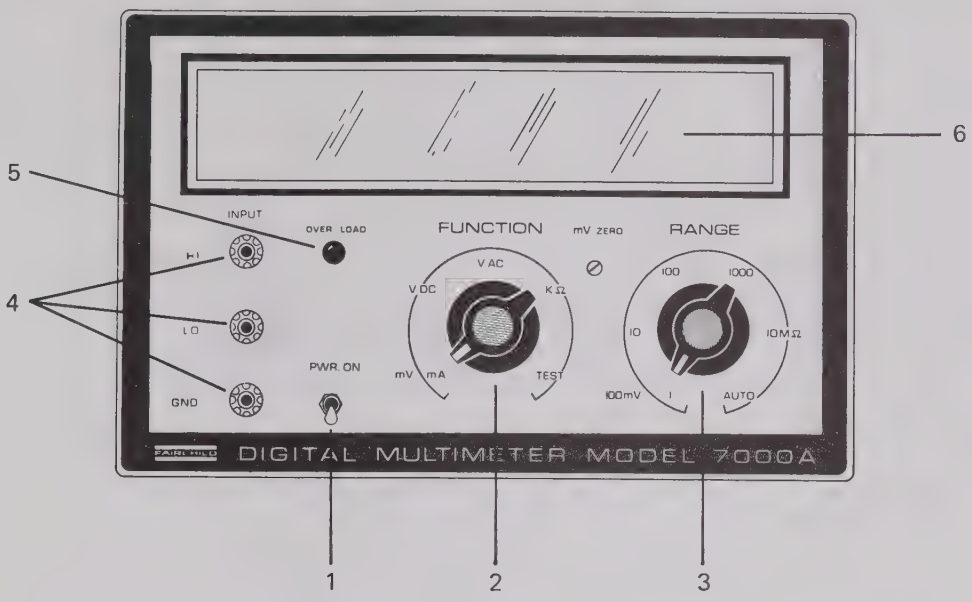
The terminals must be used correctly to reduce ground loop currents to a minimum and achieve best measurement accuracy. When measuring a low level, high impedance source with its own ground, connect GND terminal to the source ground and the HI and LO terminals to the high and low outputs of the source. For all other measurements connect the GND and LO terminal to one measurement point and the HI terminal to the other.

5. If OVERLOAD indicator is flashing, input voltage is beyond measurement range of instrument. Disconnect instrument from voltage source.
6. Read voltage on display. Decimal point is correctly positioned. Measurement unit (V DC) and polarity are displayed.

CAUTION

THE MEASURING CIRCUIT IS FLOATED FROM THE CHASSIS GROUND OF THE INSTRUMENT. THE POTENTIAL APPLIED BETWEEN LO AND GND MUST NOT EXCEED 500 V OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Figure 3-5. DC Voltage Measurement, Auto Ranging



1. Connect instrument to AC power source. Set PWR ON switch to ON.

2. Set FUNCTION switch to mV.

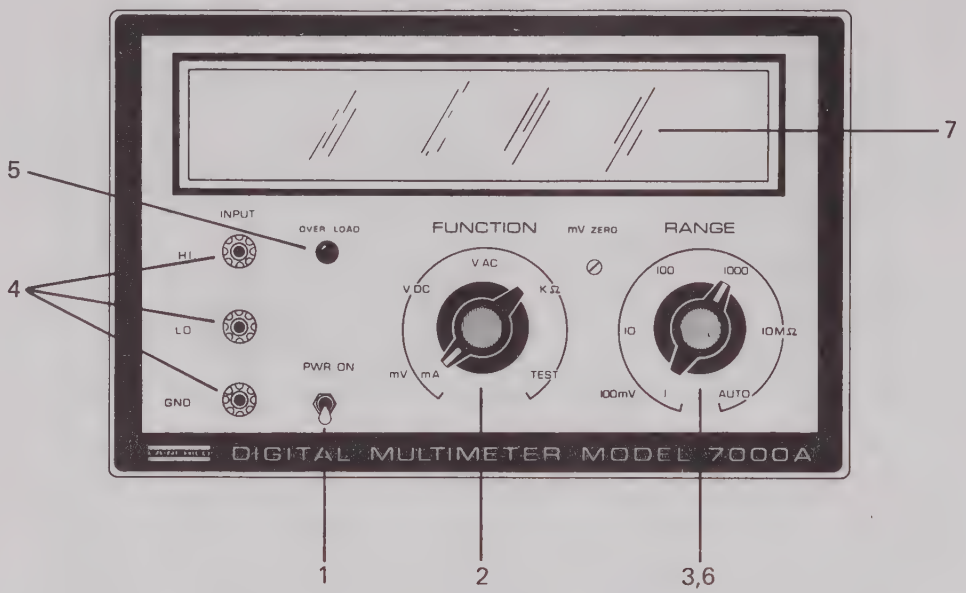
3. Set RANGE switch to 100 mV.

4. Connect HI, LO and GND terminals to unknown DC voltage source. Voltage amplitude must be within range 0 to ± 120.00 mV.

5. If OVERLOAD indicators is flashing, input voltage is beyond measurement range of instrument. Disconnect instrument from voltage source.

6. Read voltage on display. Decimal point is correctly positioned. Measurement unit (mV) and polarity are displayed.

Figure 3-6. DC mV Measurement

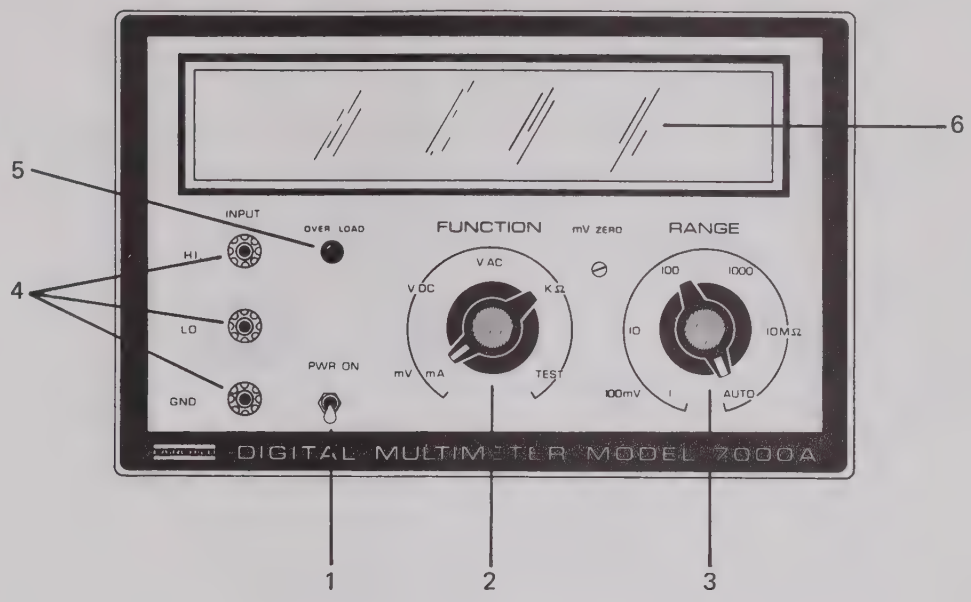


1. Connect instrument to AC power source. Set PWR ON switch to ON.
2. Set FUNCTION switch to MA DC.
3. Set RANGE switch to 1000.
4. Connect HI, LO, and GND terminals to DC current source.
5. If OVERLOAD indicator is flashing, input current is beyond measurement range of instrument. Disconnect from current source.
6. Progressively select lower RANGE settings until corrent range is reached.
7. Read DC current on display. Decimal point is correctly positioned and measurement unit (MA DC) is displayed.

CAUTION

A MAXIMUM OF 2 AMPERES MAY BE APPLIED TO ANY RANGE WITHOUT DAMAGE.

Figure 3-7. DC Current Measurement, Manual Ranging

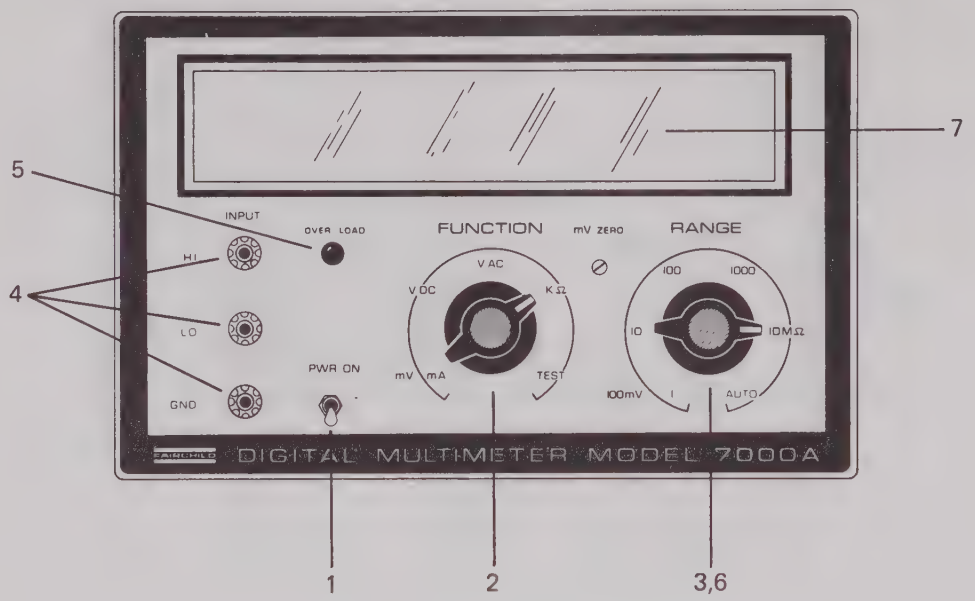


1. Connect instrument to AC power source. Set PWR ON switch to ON.
2. Set FUNCTION switch to MA DC.
3. Set RANGE switch to AUTO.
4. Connect HI, LO, and GND terminals to DC current source.
5. If OVERLOAD indicator is flashing, input current is beyond measurement range of instrument. Disconnect from current source.
6. Read DC current on display. Decimal point is correctly positioned and measurement unit (MA DC) is displayed.

CAUTION

A MAXIMUM OF 2 AMPERES MAY BE APPLIED TO ANY RANGE WITHOUT DAMAGE.

Figure 3-8. DC Current Measurement, Auto Ranging

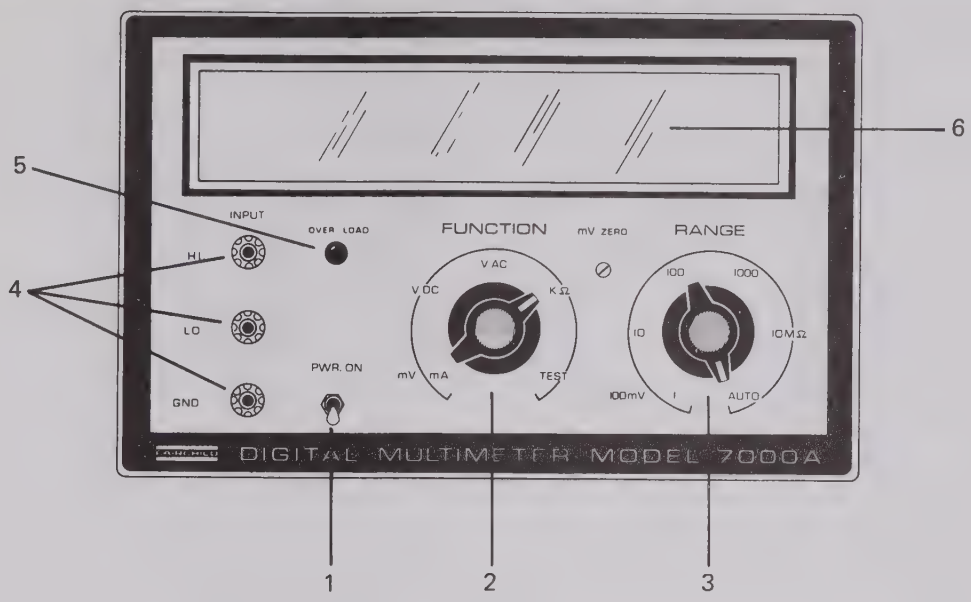


1. Connect instrument to AC power source. Set PWR ON switch to ON.
2. Set FUNCTION switch to KΩ.
3. Set RANGE switch to 10 MΩ.
4. Connect unknown resistance between HI and LO terminals.
5. If OVERLOAD indicator is flashing, value of resistance under test is beyond measurement range of instrument.
6. Progressively select lower RANGE settings until correct range is reached.
7. Read resistance on display. Decimal point is correctly positioned and measurement unit (KΩ) is displayed.

CAUTION

DO NOT CONNECT A CONSTANT VOLTAGE SOURCE TO THE INSTRUMENT WITH THE FUNCTION SWITCH IN THE KΩ POSITION. VOLTAGE IN EXCESS OF 200 V WILL DAMAGE THE INSTRUMENT.

Figure 3-9. Resistance Measurement, Manual Ranging

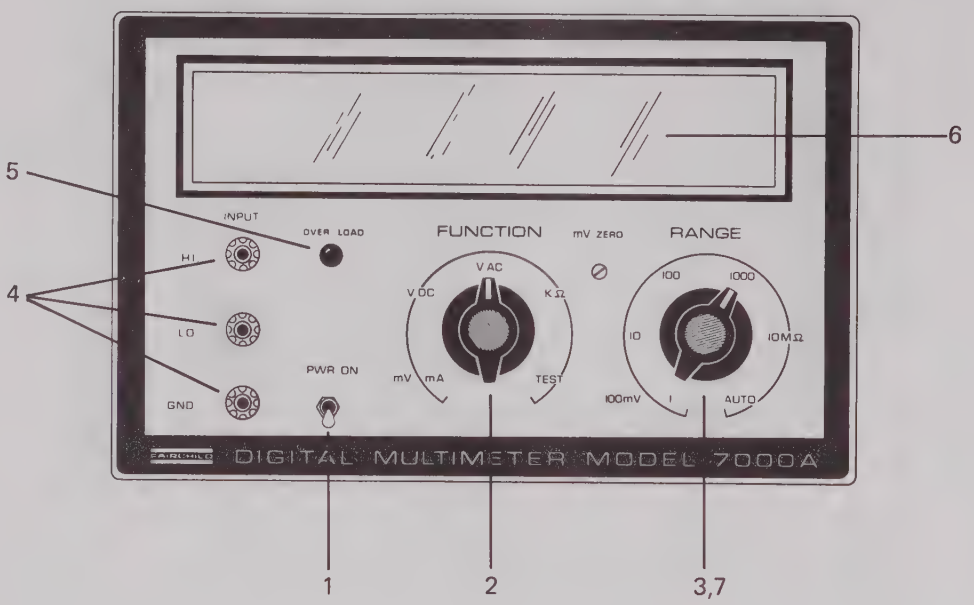


1. Connect instrument to AC power source. Set PWR ON switch to ON.
2. Set FUNCTION switch to KΩ.
3. Set RANGE switch to AUTO.
4. Connect unknown resistance between HI and LO terminals.
5. If OVERLOAD indicator is flashing, value of resistance under test is beyond measurement range of instrument.
6. Read resistance on display. Decimal point is correctly positioned and measurement unit (KΩ) is displayed.

CAUTION

DO NOT CONNECT A CONSTANT VOLTAGE SOURCE TO THE INSTRUMENT WITH THE FUNCTION SWITCH IN THE KΩ POSITION. VOLTAGE IN EXCESS OF 200 V WILL DAMAGE THE INSTRUMENT.

Figure 3-10. Resistance Measurement, Auto Ranging



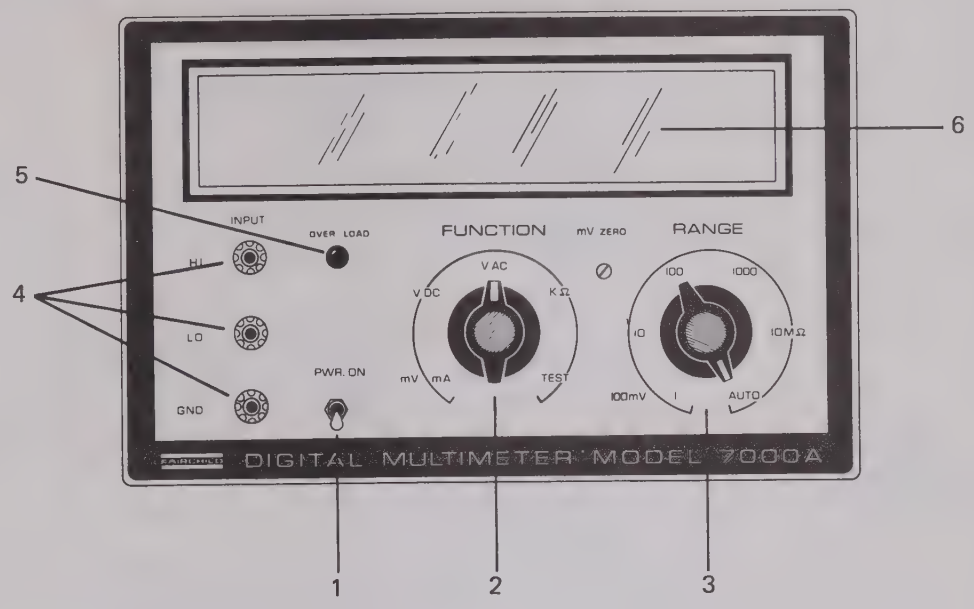
1. Connect instrument to AC power source. Set PWR ON switch to ON.
2. Set FUNCTION switch to V AC.
3. Set RANGE switch to 1000.
4. Connect HI, LO, and GND terminals to AC voltage source.
5. If OVERLOAD indicator is flashing, input voltage is beyond measurement range of instrument. Disconnect from voltage source.
6. Read AC voltage on display. Decimal point is correctly positioned and measurement unit (V AC) is displayed.
7. Progressively select lower RANGE settings until correct range is reached.

CAUTION

MAXIMUM ALLOWABLE INPUT VOLTAGE IS FREQUENCY-DEPENDENT. DO NOT EXCEED LIMITS LISTED BELOW OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Frequency	Maximum Input Voltage
50 Hz to 10 kHz	750 V
10 kHz to 30 kHz	500 V
30 kHz to 100 kHz	350 V

Figure 3-11. AC Volts Measurement, Manual Ranging



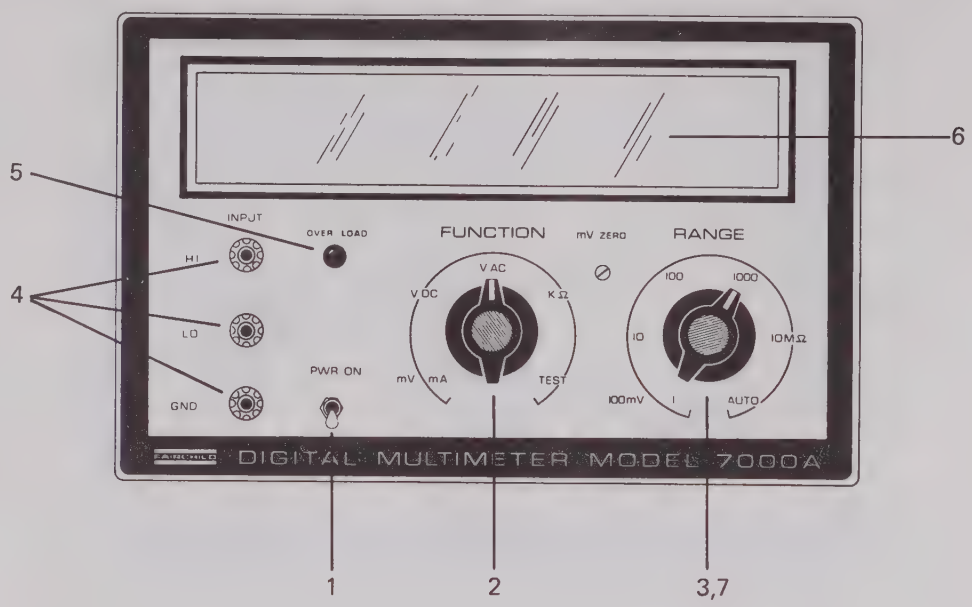
1. Connect instrument to AC power source. Set PWR ON switch to ON.
2. Set FUNCTION switch to V AC.
3. Set RANGE switch to AUTO.
4. Connect HI, LO, and GND terminals to AC voltage source.
5. If OVERLOAD indicator is flashing, input voltage is beyond measurement range of instrument. Disconnect from voltage source.
6. Read AC voltage on display. Decimal point is correctly positioned and measurement unit (V AC) is displayed.

CAUTION

MAXIMUM ALLOWABLE INPUT VOLTAGE IS FREQUENCY-DEPENDENT. DO NOT EXCEED LIMITS LISTED BELOW OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Frequency	Maximum Input Voltage
50 Hz to 10 kHz	750 V
10 kHz to 30 kHz	500 V
30 kHz to 100 kHz	350 V

Figure 3-12. AC Volts Measurement, Auto Ranging



1. Connect instrument to AC power source. Set PWR ON switch to ON.
2. Set FUNCTION switch to V AC.
3. Set RANGE switch to 1000.
4. Connect HI, LO, and GND terminals to AC voltage source.
5. If OVERLOAD indicator is flashing, input voltage is beyond measurement range of instrument. Disconnect from voltage source.
6. Read AC voltage on display. Decimal point is correctly positioned and measurement unit (V AC) is displayed.
7. Progressively select lower RANGE settings until correct range is reached.

CAUTION

MAXIMUM ALLOWABLE INPUT VOLTAGE IS FREQUENCY-DEPENDENT. DO NOT EXCEED LIMITS LISTED BELOW OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Frequency	Maximum Input Voltage
50 Hz to 10 kHz	750 V
10 kHz to 30 kHz	500 V
30 kHz to 100 kHz	350 V

Figure 3-11. AC Volts Measurement, Manual Ranging

Figure 4-1. Model 7000A Block Diagram

Section IV
Theory of Operation

INTRODUCTION

This section contains a discussion of the design and operating principles of the Fairchild Model 7000A Digital Multimeter. Theory of operation is discussed first at block diagram level and then at detailed circuit level. Complete schematic diagrams of circuits discussed in this section are included in Section V of the manual.

BASIC OPERATING PRINCIPLES

Figure 4-1 is a block diagram of the multimeter. In order to describe the basic measurement technique, assume that the DC volts mode (V DC) of operation has been selected. (This function is chosen because the DC measurement circuitry is common to all modes of operation; the additional conversion required for optional measurement of resistance, DC current and AC voltage is described in later paragraphs.) The DC input voltage is coupled via DC attenuator A8 to input amplifier A7. This unit is a solid-state chopper-stabilized operational amplifier with a floating power supply and is connected to produce an output current directly proportional to the amplitude of the input voltage. Ranging resistors in the attenuator and the amplifier transconductance resistance are selected by the front panel RANGE switch (or automatically by optional auto-ranging assembly A4) to provide the same current level for each of the four input voltage ranges. The output of the amplifier is connected to a current rectifier on assembly A6 which gives an output current that is equal to the input current in magnitude, but is of negative polarity, regardless of the input current polarity. The current rectifier serves two purposes: it supplies a current proportional to the voltage being measured to integrating capacitor A6C5/A6C6 and it senses the polarity of the input voltage for display on the readout polarity indicator.

A measurement cycle consists of two parts. See figure 4-2. The first portion begins when the start circuit (a free-running multivibrator) generates a start pulse. The leading edge, (t_1 on figure 4-2) resets the decade counting units to 00000 and the trailing edge (t_2) sets the input flip-flop. The input flip-flop "IN" output closes solid-state switch A6Q7, coupling the output of the current rectifier to integrating capacitor A6C5/A6C6. Simultaneously, the input flip-flop "IN" output controls a zero detector which (a) enables the clock, allowing clock pulses to pass to the first decade of the counting unit and (b) opens solid-state switch A6Q12, removing ground from integrating capacitor A6C5/A6C6. The output of the current rectifier now charges the integrating capacitor and clock pulses feed into the counter. The counter can hold 10,000 counts before overflowing to 00000. The four least significant digits are obtained from decade counters and the most significant digit from a binary counter that indicates 0 and 1 only. When overflow occurs (t_3), a full scale pulse is generated that resets the input flip-flop.

The second portion of the measurement cycle now begins. The input flip-flop (a) disconnects the integrating capacitor for the output of the current rectifier and connects it instead via solid-state switch A6Q10 to a precision 1 mA constant current source having a posi-

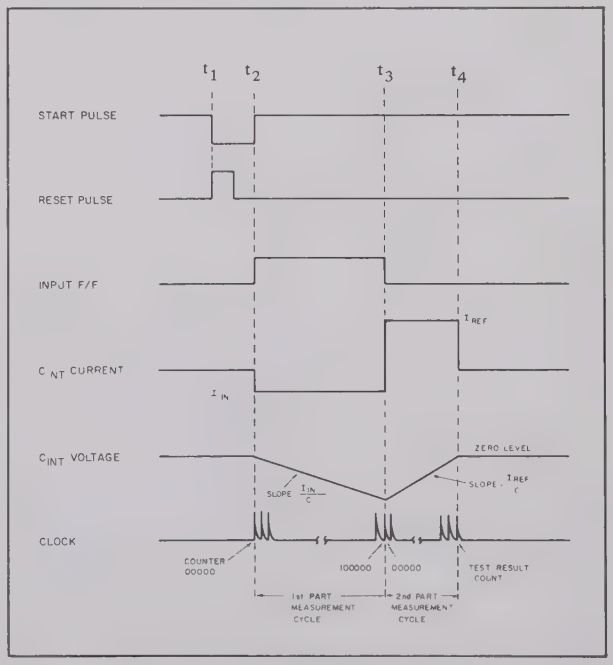


Figure 4-2. Test Sequence Timing

tive output, and (b) removes its control from the zero detector. However, due to the negative charge on the integrating capacitor at this time, the zero detector continues to allow clock pulses to reach the counter. The charge on the integrating capacitor returns to zero at a constant rate because the reference current is derived from a reference source that is stabilized and temperature compensated to a high degree. The time required for the charge to reach zero is proportional to the integrated unknown input current. Pulses counted during this period (t_3 to t_4) accumulate in the decade counter. The zero detector senses when the charge on the integrating capacitor reaches zero and when this occurs, the clock is inhibited. The instrument now holds the measured value and the decimal readout values are gated to show the counter setting. Counter capacity, clock frequency, and ranging are designed to give a readout in volts. When the input signal exceeds the range setting, an overload indicator (a flashing red light) is activated. Input to the overload indicator is taken from the binary counter so that as the most significant digit is counted the overload indicator is activated.

When V AC is selected, the AC signal is converted to an equivalent DC voltage which then is measured by the DC volts circuitry previously described. The output of optional V AC assembly A9 produces a DC level proportional to the average value of the applied AC voltage. The instrument, however, is calibrated in such a manner that the rms value of a pure sine wave is indicated.

DC current is measured by monitoring the voltage drop across a number of precision instrument shunts mounted on optional assembly A14. For all DC current ranges, the full scale voltage drop developed across the shunt resistors is 1.0 V.

Resistance is measured by programing a constant current through the unknown resistance and measuring the resulting voltage drop with the basic DC measurement system. The optional ohms converter circuitry is mounted on assembly A10.

DC VOLTAGE MEASUREMENT

Figure 4-3 is a diagram of the DC measurement circuit showing in detail the operation of the function select switch and ranging relays. When either the 1 V DC or

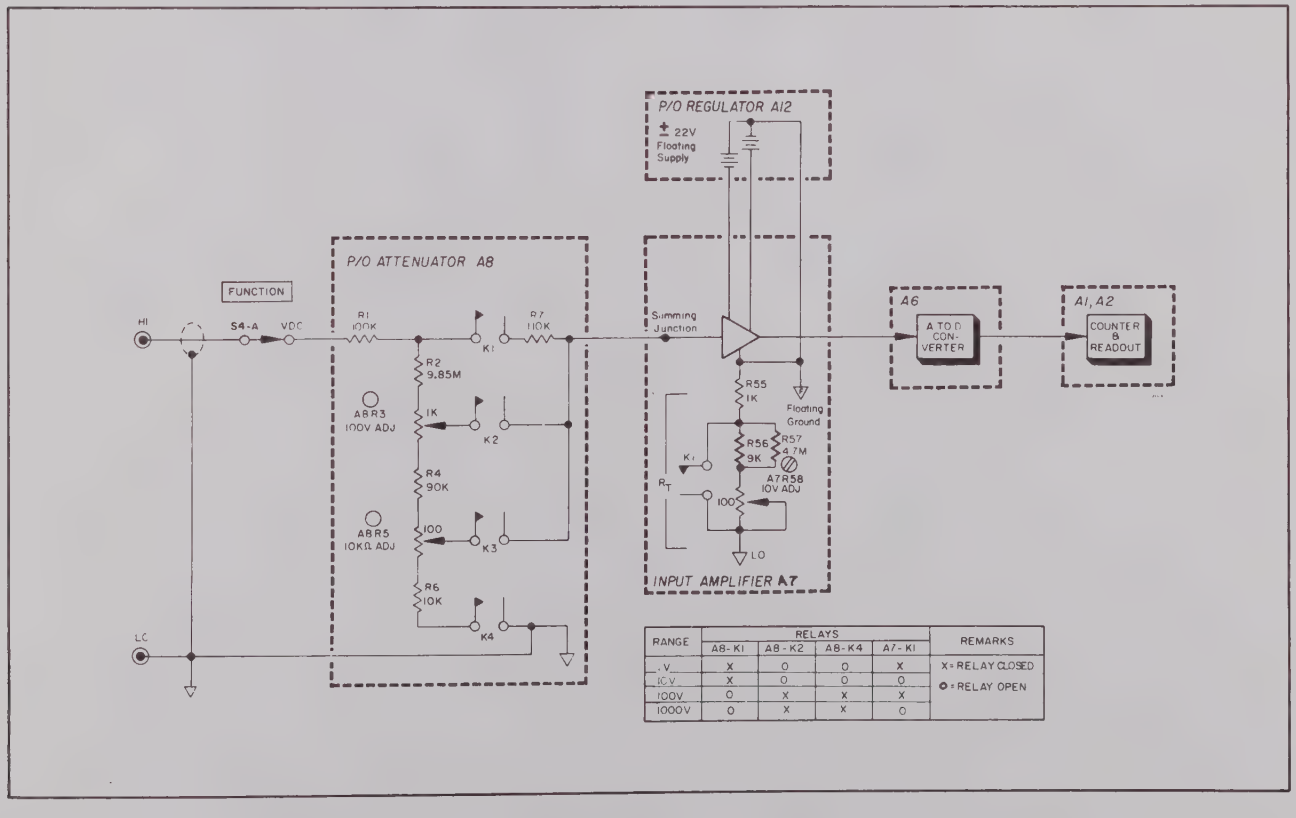


Figure 4-3. Basic Circuit, DC Volts Measurement

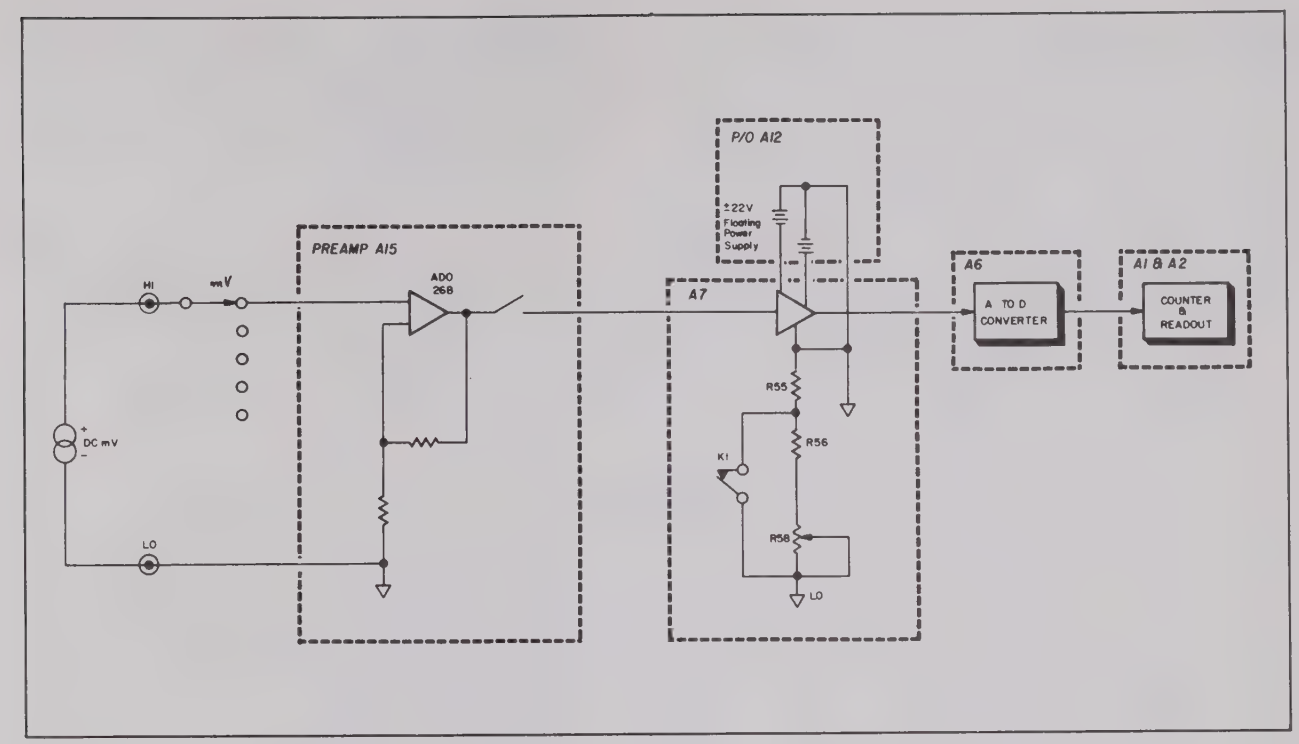


Figure 4-4. Basic Circuit, DC mV Measurement

10 V DC range is selected, relay A8K1 is closed by the function logic and applies the unknown voltage directly to the input of the chopper stabilized amplifier on assembly A7. (The amplifier is described in detail on page 4-7.).) The input impedance of the amplifier is $>10^9$ Ω, and this is essentially the input impedance of the instrument on the 1 V DC and 10 V DC ranges. The amplifier generates a current that is proportional to the value of the input voltage, and an output of 1 mA full scale is chosen for all ranges. The amplifier transconductance resistor R_t is selected by relay A7K1 to program this current. For the 1 V DC range, A7K1 is closed and R_t = 1 kΩ; for the 10 V DC range A7K1 is open and R_t = 10 kΩ.

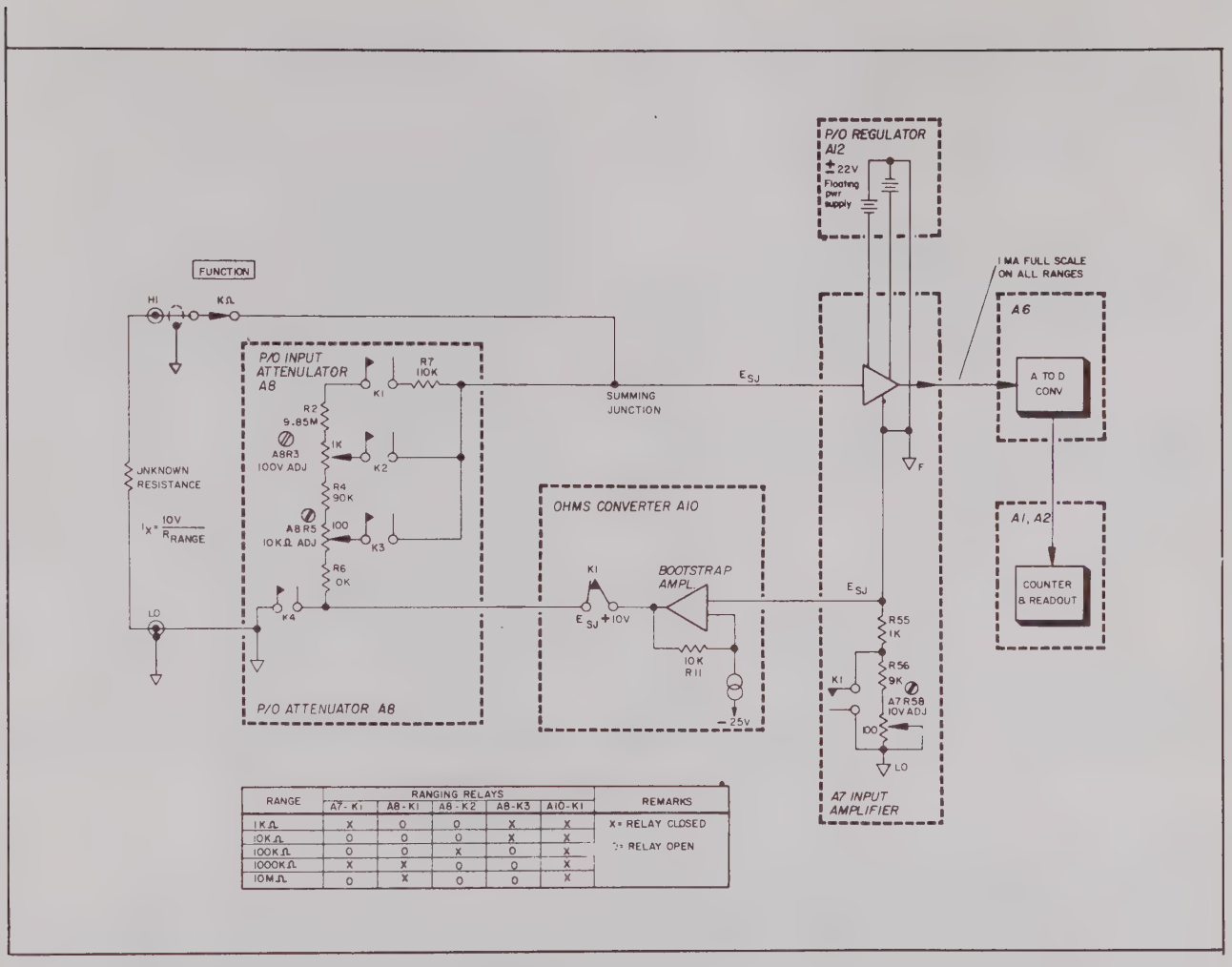
On the 100 V DC and 1000 V DC ranges, A8K1 is held open and A8K4 closed. This connects the input signal across a 100: 1 attenuator network consisting of A8R2 through A8R6. On both the ranges, A8K2 is closed and picks off 1 V for a 100 V input and 10 V for a 1000 V input. Again, relay A7K1 is operated to give the chopper stabilized amplifier a 1 mA full scale current for a 1 V and 10 V input. (100 V DC and 1000 V DC ranges respectively.) The input impedance of the instrument on the two upper ranges is set by the resistance of the attenuator network at 10 MΩ.

DC MV MEASUREMENT

The basic mV measurement circuit is shown in figure 4-4. When the 100 mV readout range is selected, the DC input voltage (up to 120 mV) is amplified 10 times by pre-amplifier assembly A15 and applied to the DC measurement discussed previously. The DC circuit is preset to the 1 V range with the decimal point and with readout set to indicate a full scale range of 100 mV.

RESISTANCE MEASUREMENT

Resistance is measured by programing a constant current through the unknown resistance and measuring the resulting voltage drop with the basic DC measurement system. A block diagram of the resistance measurement circuit is shown in figure 4-5. Relay A10K1 is closed by the function logic when the kΩ mode is selected. A feedback circuit consisting of bootstrap amplifier A10 and ranging resistors programed by relays A8K1, A8K2 and A8K3 acts as a constant current generator to supply a test current of 1 μA, 100 μA or 1 mA. The bootstrap amplifier output is equal to the voltage at the summing junction (input of amplifier A7) plus 10 V. This maintains 10 V across the current programing resistance. The test current through the unknown resistance is therefore



RANGE	RANGING RELAYS A7-K1	A8-K1	A8-K2	A8-K3	A10-K1	REMARKS
1KΩ	X	0	0	X	X	X= RELAY CLOSED
10KΩ	0	0	0	X	X	0= RELAY OPEN
100KΩ	0	0	X	0	X	
1000KΩ	X	X	0	0	X	
10MΩ	0	X	0	0	X	

Figure 4-5. Basic Circuit, Resistance Measurement

$10\ V/R_{Range}$. The DC voltage appearing at the input of amplifier A7 is proportional to the value of unknown resistance. By suitable switching of range resistors on A8 and the transconductance resistor on A7, five ranges of resistance readout can be obtained. Relay operation is summarized in figure 4-5.

Ohms Converter A10

The ohms converter is a bootstrap amplifier which provides an output voltage equal to its input voltage plus 10 V. A schematic of the circuit is shown in figure 5-25. Transistors A10Q1A and A10Q1B comprise a differential amplifier with A10Q3 and A10Q4 acting as output stages. The base of A10Q1A is tied to the floating ground on input amplifier A7 and the base of A10Q1B is connected to a 1 mA constant current generator. A feedback resistance of 10 kΩ (A10R11) is connected between the output and the inverting input (base of A10Q1B). This bootstrap configuration maintains 10 V across the feedback resistance holding the amplifier output voltage equal to the voltage level at the input plus 10 V. The constant current generator comprises A10Q5, A10Q6, A10Q7 and A10Q5. Zener diode CR5 provides a reference voltage of 6.8 V. This voltage is maintained across A10R19, causing a constant current of 1 mA to flow in the collector circuit of A10Q7A. Feedback between the output and i input is via resistors A10R14, A10R13, A10R12, A10R11 and potentiometer A10R8. The shorting links across A10R12, A10R13, and A10R14 may be removed for coarse adjustment, and A10R8 allows for fine adjustment..

AC VOLTAGE MEASUREMENT

When the V AC function is selected, the AC input signal is converted to an equivalent DC voltage which is then

measured by the DC circuitry previously described. The input is applied via attenuator A4 to the AC-to-DC converter A9 which produces a DC level proportional to the average value of the applies AC. The instrument, however, is calibrated so that the rms value of a pure sine wave is indicated at the readout.

AC-DC Converter A9

The AC to DC Converter consists of an input attenuator, a wideband amplifier with selectable negative feedback and an output filter network. See figure 4-6.. Series capacitor A9C1 blocks DC voltage so that only AC signals are measured. Relay A9K4 is closed for all AC voltage ranges. Ranging relay operation is summarized in figure 4-6. For any given range, the input attenuator employs two parallel RC networks to give a frequency independent attenuation. The attenuated signal is amplified and half-wave rectified. The rectified signal is filtered in a RC filter network and applied to the input amplifier as a DC voltage.

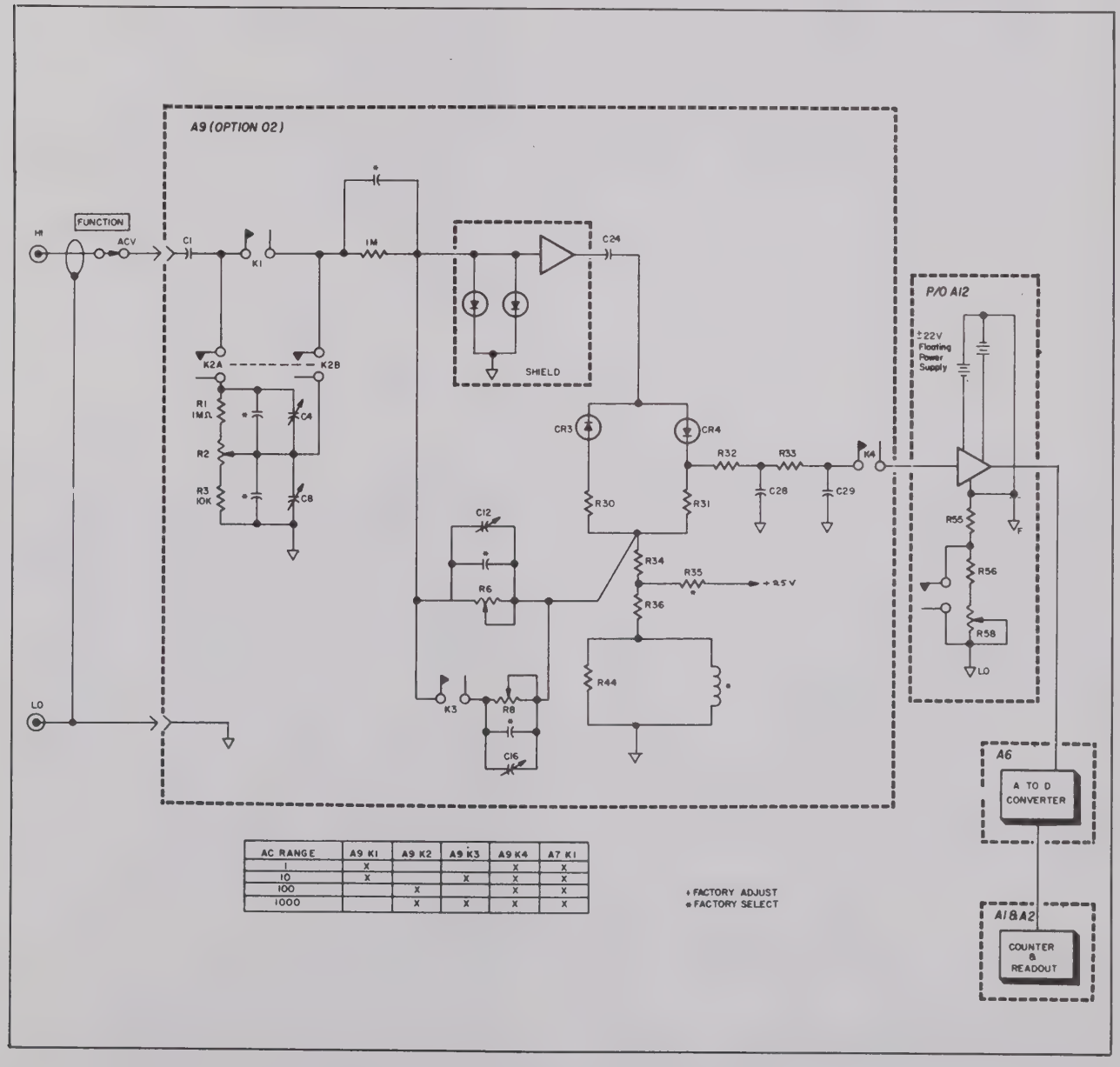


Figure 4-6. Basic Circuit, AC Volts Measurement

DC CURRENT MEASUREMENT

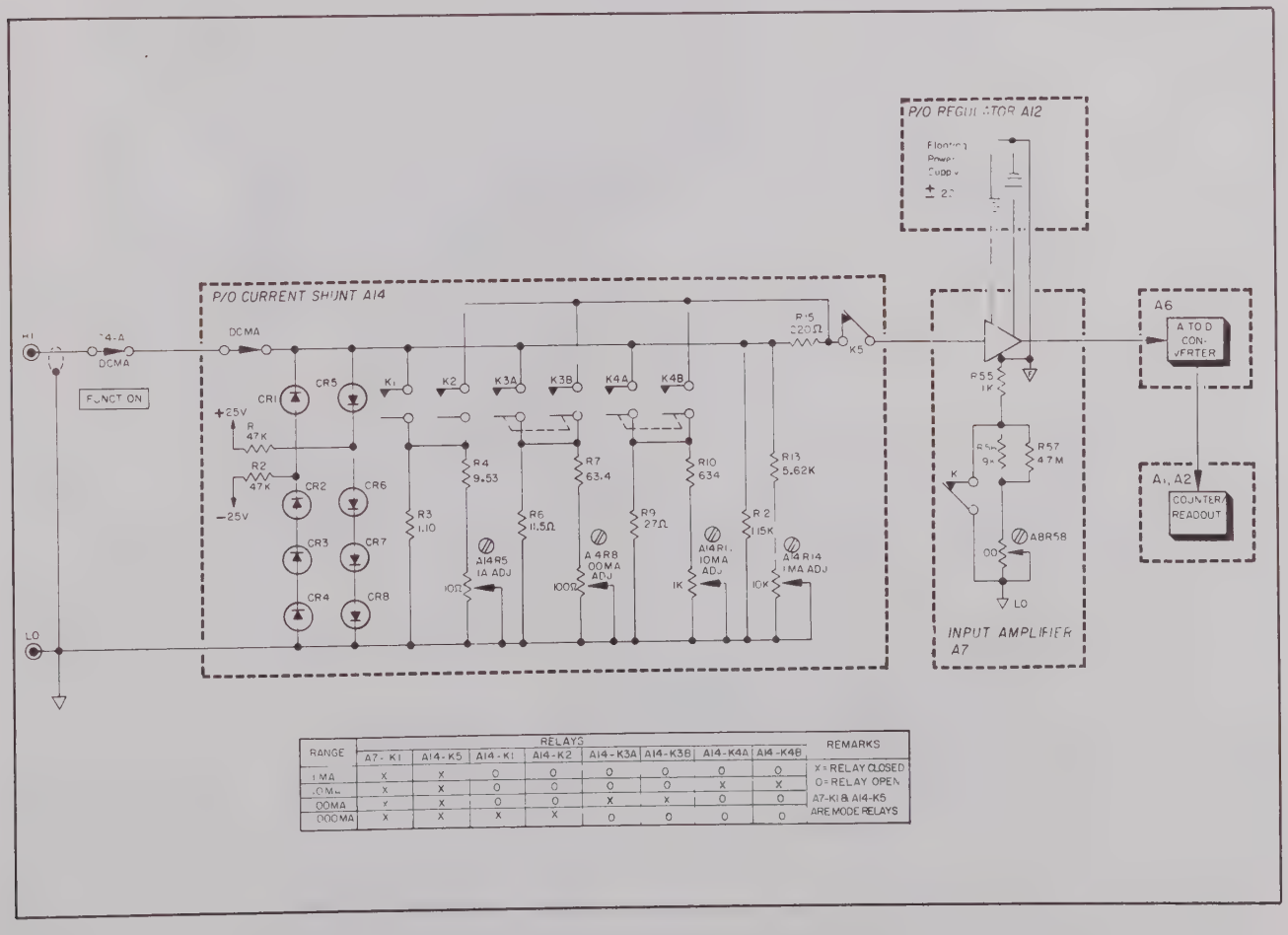
Direct current is measured by monitoring the voltage drop created when the unknown current flows through precision shunt resistors mounted on A14. The voltage drop is monitored with the basic DC measuring circuitry. Figure 4-7 is a diagram of the DC MA measuring circuit. Relays A7K1 and A14K5 are energized by the function logic when the MA mode is selected by the front panel FUNCTION switch. The action of the ranging relays is also shown in figure 4-7. In each range, shunt resistances are selected to give a full scale input of 1 V to the DC circuit. The relay circuit connecting the shunts into circuit employs a 4-point Kelvin configuration with voltage sensing whereby the voltage drop across the shunt relay and associated wiring does contribute to the measurement and cause a readout error. This feature is especially significant when performing high current measurements. Diodes A14CR1 through A14CR8 form a clamp to protect the instrument from excessive voltages applied at the input.

SELF CHECK TEST

When TEST is selected on the front panel FUNCTION switch, the function logic energizes relay A8K5. With A8K5 closed, a path is provided from the variable voltage tap A8R9, TEST ADJ (see figure 4-8) to the input amplifier A7. Zener diode A8CR1 gives a stable reference voltage of 6.6 V. Variable resistor A8R9 is adjusted at the factory for a 1 V input to input amplifier A7. When the instrument is operating properly the resulting readout should be 0.1000 ± 1 digit on the (1) range.

JUMPER BOARD A11

Assembly A11 is a jumper board used in place of current shunt board A14 when the DC MA measurement option is not fitted. Its purpose is to provide a connecting path from the LO INPUT terminal to the "LO OUT" connection on other PC boards.



RANGE	RELAYS								REMARKS
	A7-K1	A14-K5	A14-K1	A14-K2	A14-K3A	A14-K3B	A14-K4A	A14-K4B	
1MA	X	X	0	0	0	0	0	0	X = RELAY CLOSED
10MA	X	X	0	0	0	0	X	X	0 = RELAY OPEN
100MA	X	X	0	0	X	X	0	0	A7-K1 & A14-K5 ARE MODE RELAYS
1000MA	X	X	X	X	0	0	0	0	

Figure 4-7. Basic Circuit DC mA Current Measurement

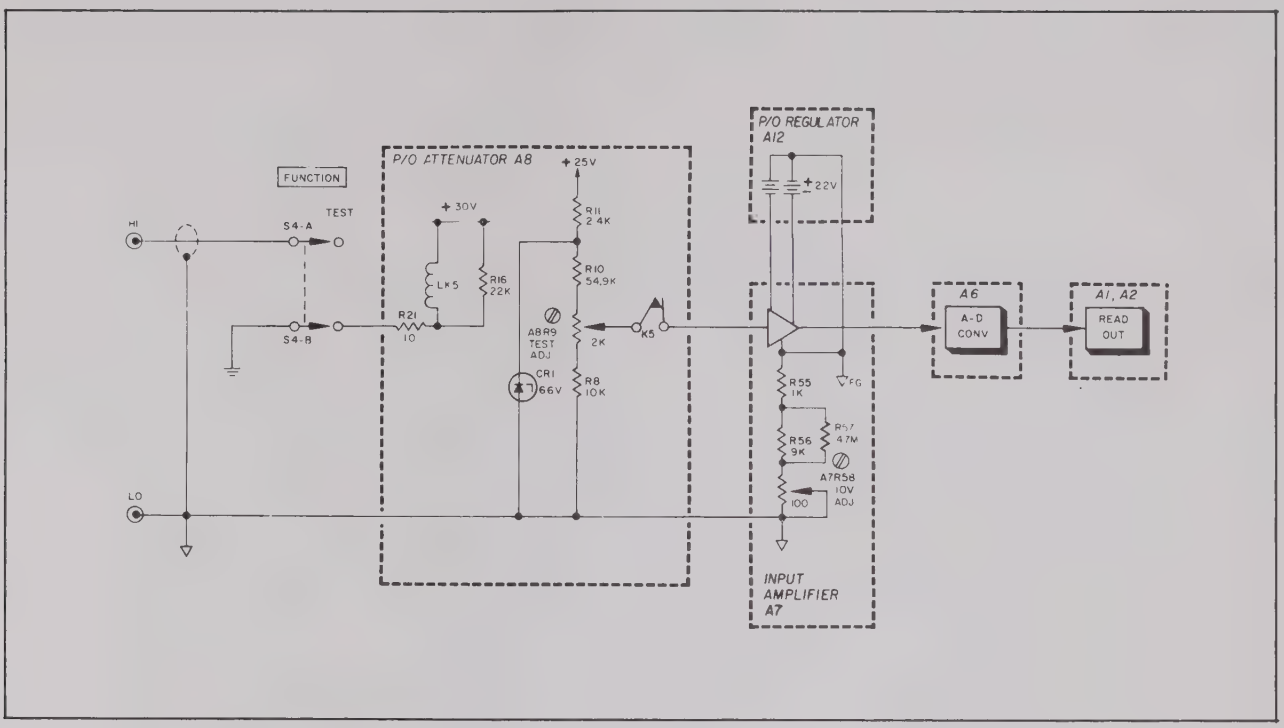


Figure 4-8. Basic Circuit, Self Check Test

INPUT AMPLIFIER A7

The input amplifier is a high quality chopper-stabilized operational amplifier. It is connected to produce an output current proportional to its input voltage. This current output charges the integrating capacitor in the Analog-to-Digital (A-D) converter during the first half of the measurement cycle. (During the second half of the measurement cycle, the output current is discharged from the integrating capacitor at a constant rate by the instrument's current reference source.)

In operation, input to the amplifier (shown as E_{in} in figure 4-9 is either 1 V or 10 V full scale, depending upon the range setting. The circuitry following the amplifier operates on a basis of 1 mA full scale for all ranges. The amplifier transconductance resistance R_t is selected by ranging relay A7K1 to equal 1 kΩ for a 1 V full scale input (A7K1 closed), or 10 kΩ for a 10 V full scale input (A7K1 open).

Frequencies above 3 Hz are fed into differential amplifier A7Q8/A7Q22 through high pass filter A7C11, A7R23. Frequencies below 3 Hz are applied directly to AC coupled amplifier A7Q3 where they are modulated, amplified and demodulated. Chopper modulator A7Q2 is a MOS FET which is switched at a 250 Hz rate. The MOS FET is utilized because of its extremely high input impedance and wide temperature operating range. The input impedance of the amplifier is greater than 100 MΩ and this essentially is the input impedance of the multimeter for its two lowest ranges. The demodulated signal is fed into the positive gain input of the differential amplifier A7Q8, A7Q22. The 15 V clamp in the input circuit of the amplifier protects it from damage due to overload. For small signal inputs the clamp has no effect on the amplifier input, because diodes CR3 and CR4 are reverse biased. For inputs with an amplitude in excess of +15 V, diodes CR6 and CR3 are forward biased and zener diode CR2 clamps the input to +15 V (plus the small voltage drop across CR5 and CR4). When the input signal becomes more negative than −15 V, diodes CR5 and CR3 are forward biased and zener diode CR1 clamps the input signal to −15 V. Resistor R3 provides a path for leakage current through CR4 and CR1 when they are reverse biased.

ANALOG-TO-DIGITAL CONVERTER A6

After the unknown signal has been converted to a DC current proportional to the magnitude of the unknown input voltage, it is fed to analog-to-digital converter A6. This board contains (a) sequence control logic including

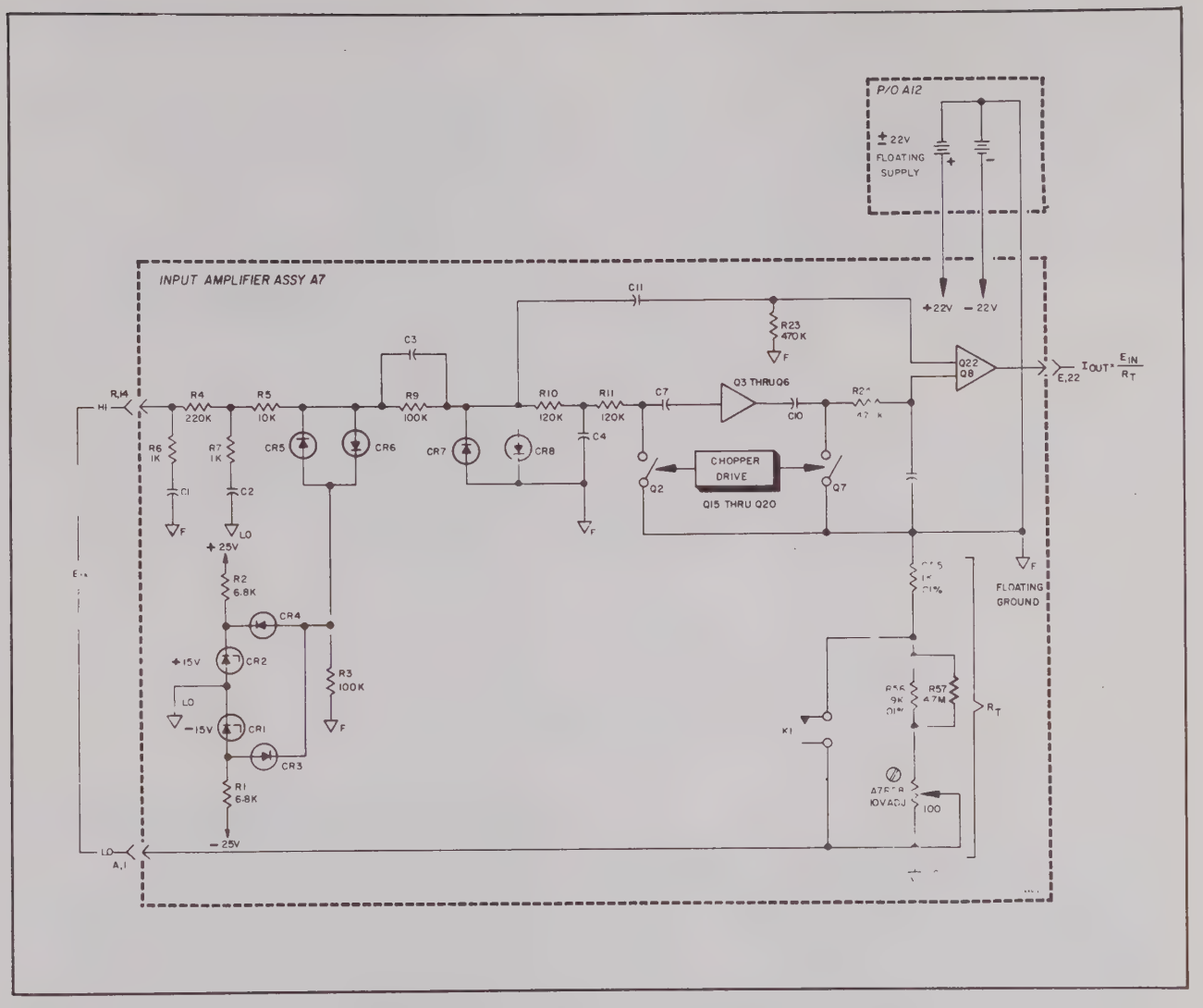


Figure 4-9. Input Amplifier

the start and reset circuits and (b) dual slope integrating circuitry including the current rectifier, reference current generator, zero detector, and clock. These circuits are discussed on page 4-8 through 4-12.

Start and Reset

The start circuit is a free-running multivibrator that produces pulses at a rate of 5 pulses per second for all modes of operation except V AC; for V AC the rate is 1 pulse per second. The leading edge of the start pulse (negative going) triggers the reset generator which in turn resets the counter to 00000. The trailing edge of the pulse (positive going) sets the input flip-flop. A simplified schematic of the start and reset generator circuits is shown in figure 4-10.

In operation, the pulse rate of the start circuit depends jointly on the RC time constant of A6C12 and A6R57/A6R72; and the reference voltage set by A6R70, A6R71. For all test modes except V AC, A6R57 and A6R72 are in parallel and give a sampling rate of approximately 5 pulses per second; for the V AC test, the V AC input from the mode logic goes to ground and only A6R57 is in circuit. This changes the sampling rate to 1 pulse per second. The output waveform is created as follows: Through regenerative coupling, A6Q19 is turned on and off alternately with A6Q20. When A6Q20 is on, the voltage at its emitter rises to +4 V and voltage divider

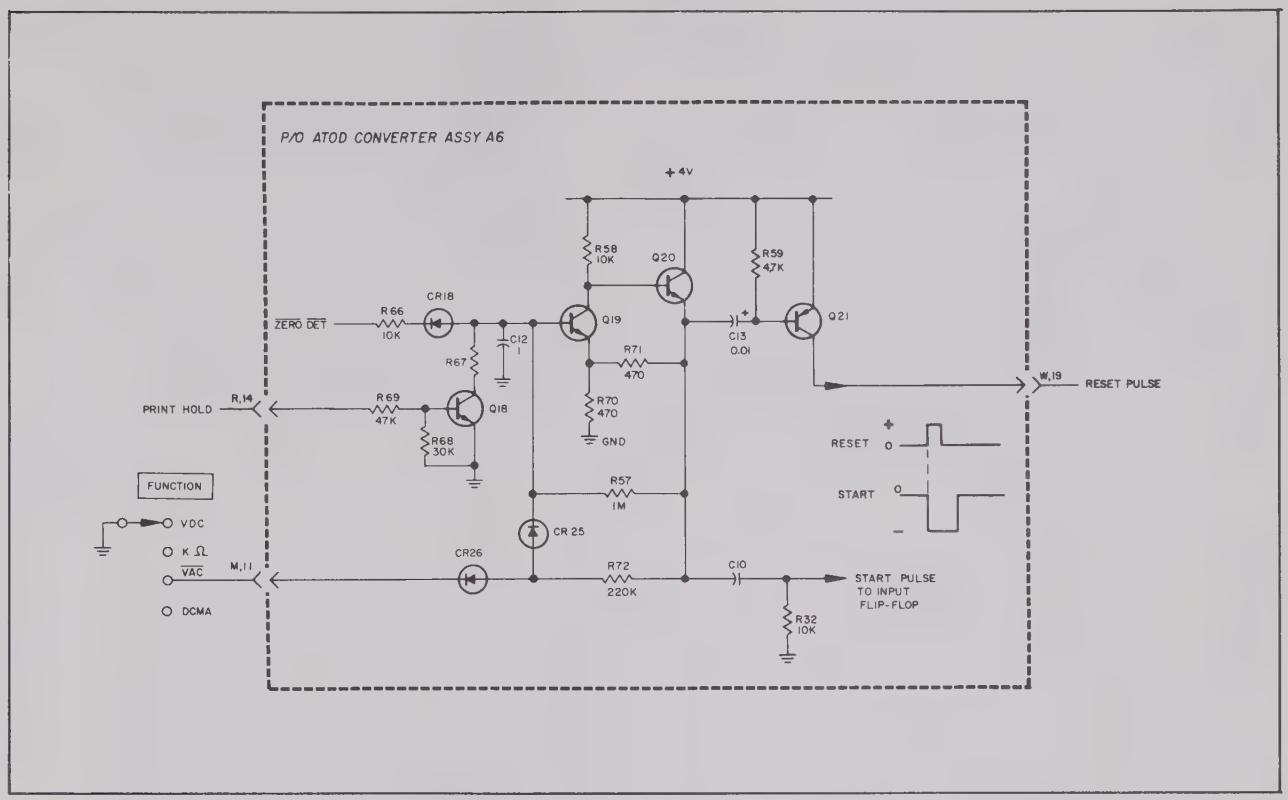


Figure 4-10. Start and Reset

A6R70, A6R71 puts 2 V on the emitter of A6Q19, holding it off. Capacitor A6C12 now starts charging to +4 V through A6R57. As the voltage across A6C12 becomes larger (approximately 2.5 V), A6Q19 is turned on, turning A6Q20 off. The emitter of A6Q20 goes low causing A6C12 to discharge through A6R57. The charge on A6C12 eventually falls too low to keep A6Q29 turned on; so A6Q19 is turned off and the cycle is repeated at a rate of 5 pulses per second. The input to the base of A6Q19 from the zero detector prevents A6C12 from charging during the time that the measurement cycle is taking place. The sample rate is thus timed from the moment that the zero detector reaches null and a readout is presented.

The reset pulse is generated by A6Q21. This transistor is normally off until triggered by the leading edge of the start pulse. At this time it generates a short positive pulse which resets the instrument circuits prior to the start of the measurement cycle (and of start pulse).

The "PRINT HOLD" circuit is provided for use with external equipment. Solid-state switch A6Q18 can be turned on by an external source. When this occurs, the voltage across A6C12 is clamped to ground and the start circuit is inhibited.

Current Rectifier

The output signal from the input amplifier is applied to a current rectifying circuit located on assembly A6. The purpose of the rectifier is to maintain the linear relationship of the input current generated by the amplifier (full scale = 1 mA), but with a constant negative polarity regardless of the polarity of the signal being measured. The basic rectifier circuit is shown in figure 4-11. For negative currents, $I_{in} = I_{out}$ through CR2. For positive currents, the signal is routed through CR1 into A6R33. This creates a voltage drop of $V_{R33} = I_{in}R33$. Negative feedback makes the voltage across A6R34: $V_{R34} = -V_{R33} = -I_{in}R33$. The current in A6R34 is the current drained from the integrating capacitor. Therefore:

$$I_{out} = -\frac{V_{R34}}{R_{34}}$$

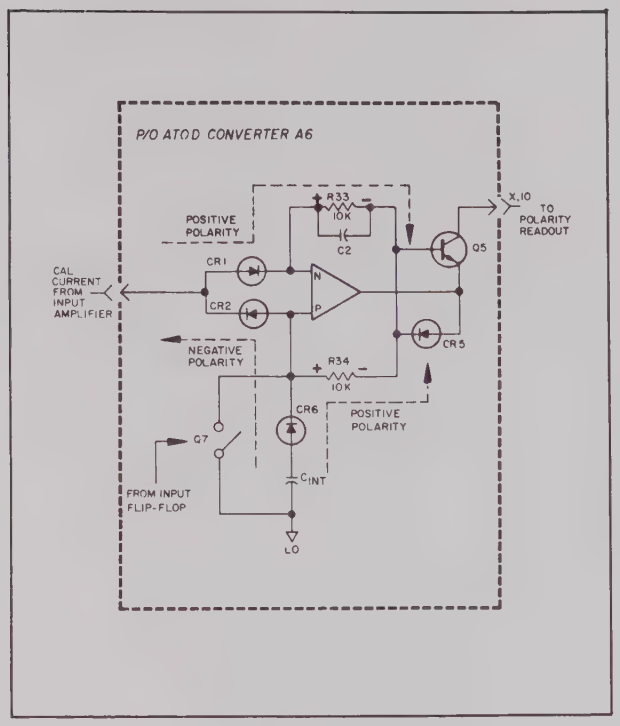


Figure 4-11. Current Rectifier

The schematic of the current rectifier is shown in figure 5-17. Transistor A6Q1 is a differential stage with A6Q2 connected as a constant current source. The output signal at the collector A6Q1B is coupled to the base of emitter follower A6Q3. The output from A6Q3 is coupled to the input of driver stage A6Q4. Feedback is via A6R33 and A6R34. Diode A6CR5 and transistor A6Q5 provide the signal controlling the (+), (–) polarity readout. When the input signal is negative (–), diode A6CR5 is nonconducting and A6Q5 is turned on.

Reference Current Generator

The reference generator supplies a positive current of 1 mA to the integrating capacitor during the second half of the measurement cycle. Figure 4-12 shows a simplified schematic of the generator. Zener diode A6CR11 produces a 6.6 V offset between differential amplifier A6Q9A/B. The differential amplifier, in an effort to adjust for zero volts across its two inputs, draws 6.6 V across resistors A6R12, A6R22, A6R23, A6R24, A6R25. By selecting a series value of 6.6 kΩ with these resistors, a full scale current of 1 mA is generated. The jumpers across A6R22/A6R24 can be removed for coarse current adjustment and the output current is adjusted to exactly 1 mA by potentiometer A6R12. Zener diode A6CR15 acts as a stable reference for A6Q11, a current source for the differential amplifier. Transistor A6Q10 is a solid-state switch used to direct the path of the generator current. During the first half of the measurement cycle, A6Q10 is held on by the "IN" signal from the input flip-flop, and current drains through A6CR8, A6CR9, A6Q10. When full scale is reached, the input flip-flop changes state allowing A6Q10 to turn off. Current from the reference generator then recharges the integrating capacitor to zero volts. At this time, the ZERO DET signal goes high and A6Q10 is turned on again.

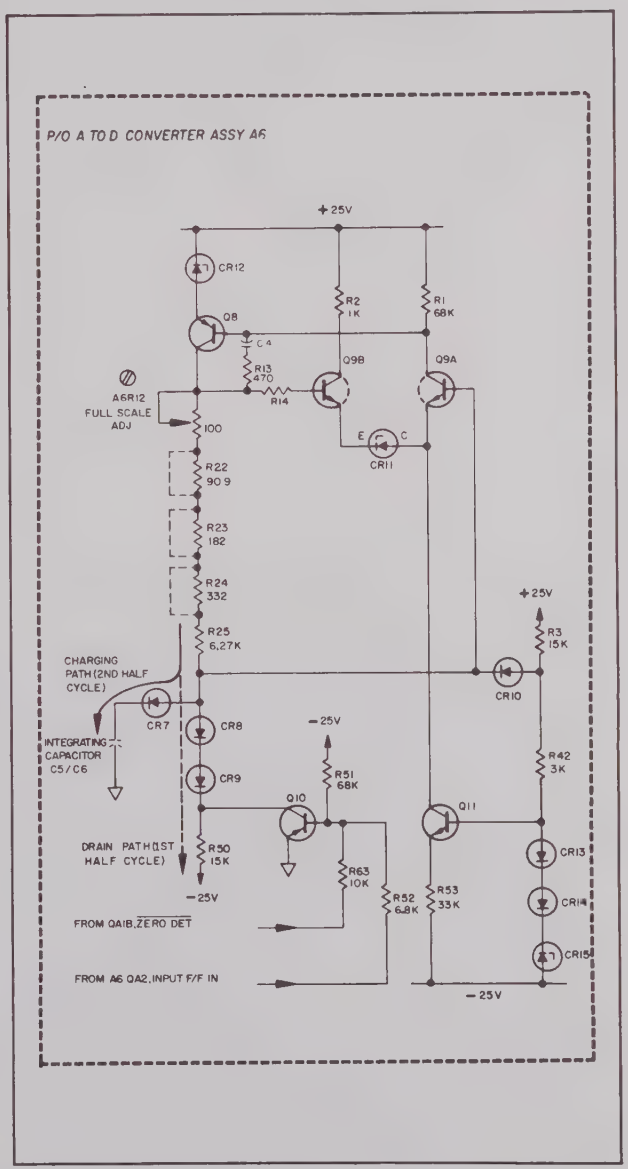


Figure 4-12. Reference Current Generator

Zero Detector

The zero detector controls operation of the clock oscillator that drives the readout counter. It allows clock pulses to reach the counter from the start of the measurement cycle until the end of the second half of the measurement cycle when the integrating capacitor is discharged back to the zero level. See timing diagram on figure 4-2.

At the start of a measurement cycle, the detector is triggered by the input flip-flop and enables the clock. The clock remains enabled until the charge on the integrating capacitor returns to zero. At this time the zero detector disables the clock until the start of the next measurement cycle. Figure 4-13 shows a simplified schematic of the detector circuit. The integrating capacitor is connected to the inverting input of differential amplifier A6Q13, and the output of the input flip-flop is connected via a voltage divider network to the noninverting input. Diode A6CR17 provides a feedback path between the amplifier output and the noninverting input. At the start of a measurement cycle the flip-flop "IN" output goes low and turns A6Q22 off, allowing the voltage at the base of A6Q13B to go high and drive amplifier A6Q13A/B. The voltage level at the collector of A6Q13B goes low while the collector voltage of A6Q13A goes high. The resulting bias voltage across the base-emitter junction of A6Q14 turns it on, and A6Q15 is turned off, Diode A6CR17 is reverse biased at

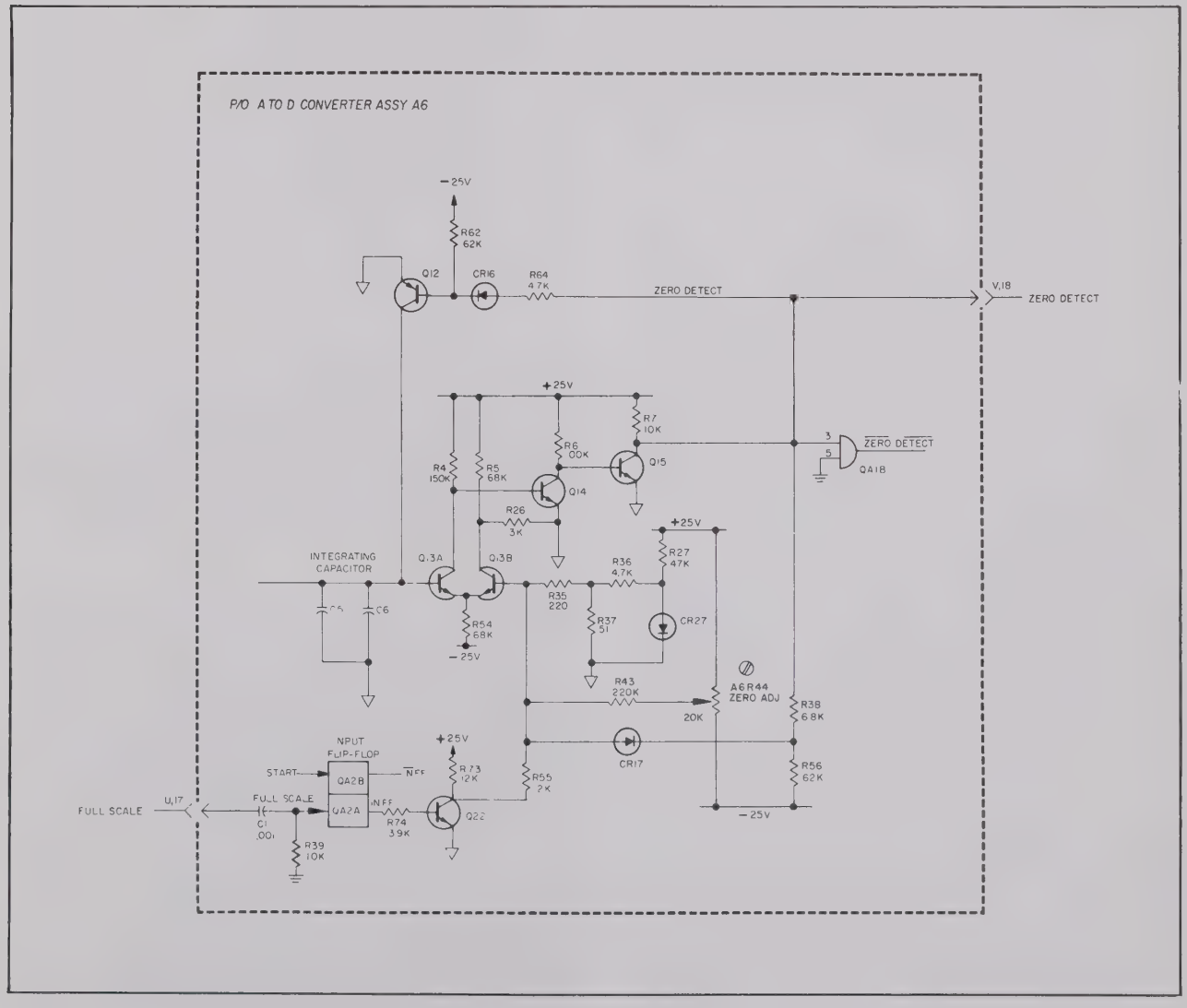


Figure 4-13. Zero Detector

this time by the positive voltage on the collector A6Q15. When the counter reaches full scale, a full scale pulse is generated which resets the input flip-flop causing its "IN" output to go high. However, the charge on the integrating capacitor is now at its maximum negative value and this keeps the amplifier locked in the state which holds A6Q15 off. As the charge on A6C5/A6C6 decreases, (becomes less negative) differential amplifier A6Q13A/B eventually allows A6Q15 to conduct. The negative collector voltage of A6Q15 now is applied to the base of A6Q13A/B and locks the zero detector in this state until zero crossover occurs.

Clock

The clock is a gated free running multivibrator that includes A6Q16 and A6Q17. See figure 4-14. At the start of a measurement cycle, the ZERO DET signal triggers the clock. The clock then sends pulses to the counter until the charge on the integrating capacitor has gone through its excursion and returned to zero. At this time, the zero detector inhibits the clock. The clock remains inhibited until the start of the next measurement cycle.

During its operation, the clock output is taken from the collector of A6Q17 and applied through "AND" gate A6QA1A to the input of the first decade counter. When the voltage at the collector of A6Q17 goes high, the voltage at pin 7 of A6QA1A goes low; when A6Q17 collector voltage goes low, the voltage at pin 7 goes to +4 V. Thus, the clock output is a series of positive pulses occurring at a rate of 200 kHz.

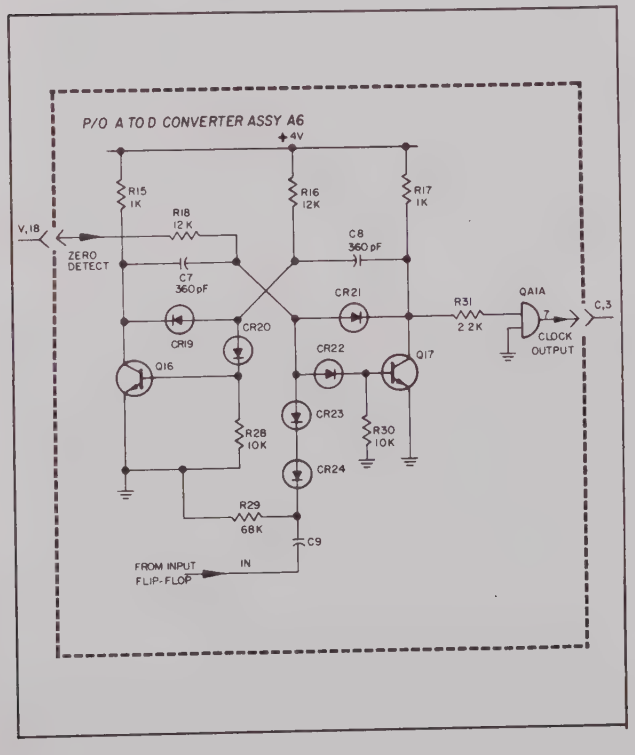


Figure 4-14. Clock

DECADE COUNTER AND COUNT READOUT ASSEMBLIES

The unit's stage of the counter and readout is shown in figure 4-15. It is typical of all four decades. The decade counter consists of four identical CμL958 integrated circuit elements. Each element consists of four cascaded binary flip-flops modified by a feedback loop to count in 1-2-4-8 binary-coded-decimal. The output pulses from the clock oscillator are fed to the first of the four cascaded counting elements and the counter accumulates the number of pulses received. Outputs (in the form of negative voltage steps) from each of the counting elements are coupled to the inputs of a μL959 Buffer/Storage unit. This allows the state of the counter output stage to be sampled and held for a controlled amount of time. In addition, it provides both true and complement signals; the true signal being presented to a CμL960 decimal Decoder/Driver, while its complementary signal is utilized as an output to the BCD circuitry.

The CμL960 Decoder/Driver accepts 1-2-4-8 BCD inputs at integrated circuit levels and produces 10 mutually exclusive outputs that directly control the ionizing potentials of a gas-filled, cold cathode indicator tube. A number—0 through 9—is presented at each readout tube in accordance with the count recorded in that particular stage.

Besides clock pulses, other circuit inputs to the counter are: A reset pulse from the measurement start circuitry on board A6, and a gate pulse generated in the zero detector on board A6. At the start of a measurement sequence, the reset pulse sets the counter to 00000. During the first half of the conversion cycle clock pulses drive the counter to 10000 and overspill (00000); during the second half, the counter advances from 00000 until the zero detector inhibits the clock, stopping the count. The signal occurring at overspill, called the FULL SCALE pulse, is fed back to the analog-to-digital circuitry and causes the changeover from one-half of the measurement cycle to the other. The number stored in the counter when the clock pulses stop is the test result. The gate pulse generated at this time changes the readout to the new count information stored in the buffer/storage elements.

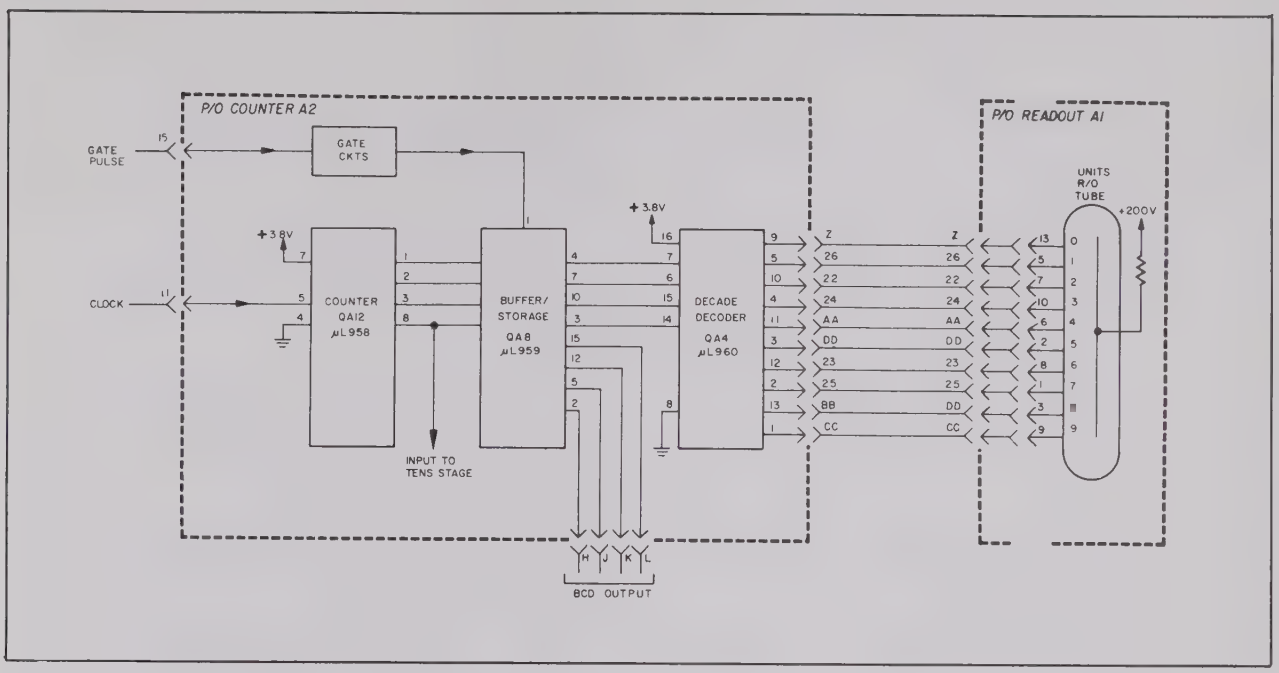


Figure 4-15. Counter and Readout - Unit's Stage

Overrange Digit

The most significant digit counter differs from the decade counters in that it can have only one of two states, either a "1" or a "0" (binary counter). When the measurement cycle begins, the counter is reset to 00000. Then, when 10000 pulses have entered the counter, the binary counter changes state back to "0", and in doing so generates the full scale pulse. This full scale pulse resets the input flip-flop previously described.

Decimal Readout

Included in the counter and readout circuitry on board A2 are four transistors that are used as decimal point drivers. See figure 5-9. When a range is selected, the decimal point driver for that range is turned on and its low going collector voltage causes the corresponding decimal point indicator to light. Four such drivers indicate all possible readout ranges of the instrument.

Polarity Indication

The polarity indicating circuit is operational during DC voltage and current measurements only. (For the other three modes no polarity indication is necessary.) When either DC V or DC MA is selected, diode A2CR6 or A2CR7 conducts, shunting current away from the base of A2Q3, turning this transistor off. With A2Q3 turned off, diodes A2CR1 and A2CR3 are reverse biased, and polarity transistors A2Q1 and A2Q2 are enabled. When functions other than DC V or DC MA are selected, A2Q3 conducts and forces A2Q1 and A2Q2 to remain off, inhibiting the polarity indicator. Polarity information from the current rectifier circuit is provided only when positive polarity input signals are sensed. In the absence of a positive polarity information from the current rectifier, negative polarity indication is automatically presented. For with no input signal, A2Q2 is held on by the positive current on its base delivered from the +200 V source through A2R8 and A2R10. When A2Q2 is turned on, its collector voltage causes the (–) cathode of POLARITY indicator A1V1 to go low. A potential difference of approximately 200 V then exists between the lamp's cathode and anode so that the lamp conducts and a negative polarity indication is given.

When input signals of positive polarity are measured with the Model 7000A, A6Q5 (which is part of the current rectifier circuit) conducts and A2Q1 is turned on. The collector of A2Q1 then goes low, pulling the (+) cathode of POLARITY indicator A1V1 low. A 200 V potential now exists between the (+) cathode and the anode of A1V1 and the (+) sign is lit. Simultaneously, a negative voltage step is applied to the BCD circuit for external data logging.

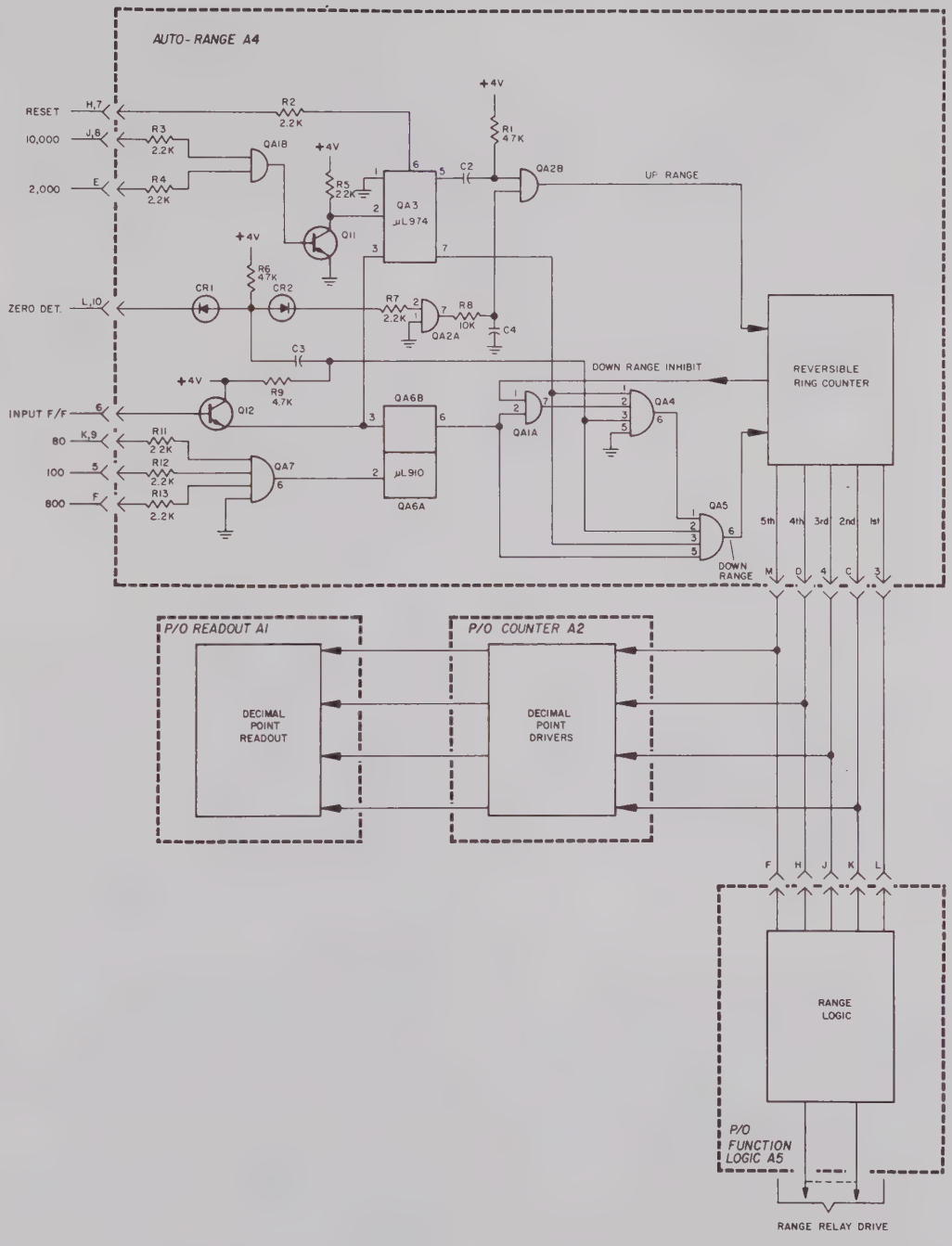


Figure 4-16. Auto-Ranging Logic

AUTOMATIC RANGING (OPTION 01)

Instrument ranging is automatic on all measurement modes of operation when the auto-ranging plug-in Option 01 is fitted. The ranging process occurs only when the input signal changes in amplitude and falls outside the prescribed limits of the range in use. These limits are 12000 and 00980. The instrument ranges up or down, according to the direction of the level change, until the correct range is found. In the absence of an input, the meter drops to the lowest range.

Basic range data is generated by a reversible ring counter with five output lines, each corresponding to a range. (A ring counter is a loop of interconnected elements, any one of which is in a specified state at any one time. Each time an input pulse is applied, the specified state advances one position in an ordered sequence around the loop. A reversible counter has two inputs--one moves the ordered sequence in one direction around the loop; the other moves it in the opposite direction.) The two inputs to the ring counter, designated up range and down range, are derived from the logic of the system decade counter. In brief this circuit:

a. Produces an up range pulse when the counter reaches 12000. (This is also a range overload condition and is detected by the overload logic.)

b. Produces a down range pulse when the zero detector reaches null before the readout exceeds 00980. This is a range condition where the readout can be given with better resolution on a lower range.

Figure 4-16 shows the logic circuitry controlling the functions described above and figures 4-17 and 4-18 show circuit timing. Each time the coutner reaches 12000, the JK complementing flip-flop element A4QA3 is triggered. The output at pin 5 is coupled to AND gate A4QA2B. The dotted lines at the right of figure 4-17 show the instrument in the correct range; the solid lines indicate production of an up range pulse.

Generation of the down range pulse is derived from AND gate A4QA2A. AND gate A4QA2A compares the output of flip-flop A4QA6A/B and the ZERO DET signal. Output of the flip-flop is low from full scale to 00980 and if null is detected during this time a down range pulse is generated. The absence of a ZERO DET signal during the same period prevents generation of the down range pulse. The dotted lines in figure 4-18 show circuit operation when the down range is not produced; the solid lines show production of the pulse.

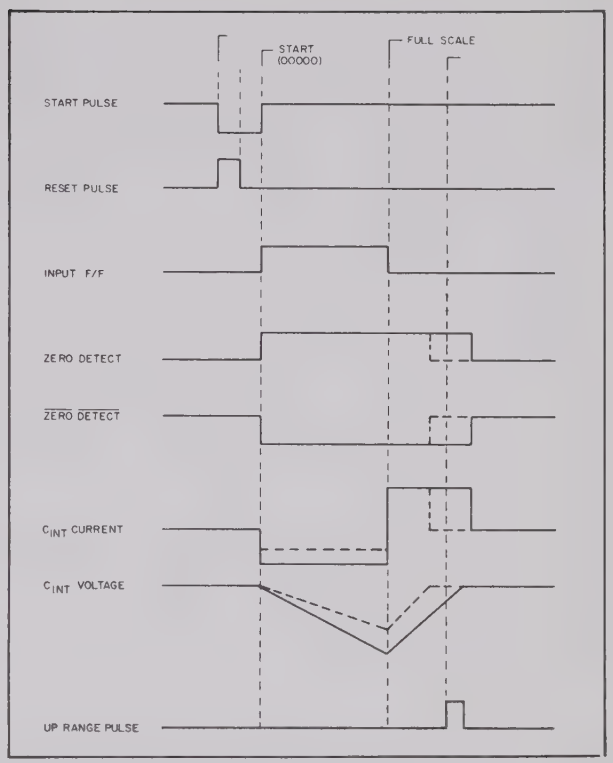


Figure 4-17. Up-Range Pulse

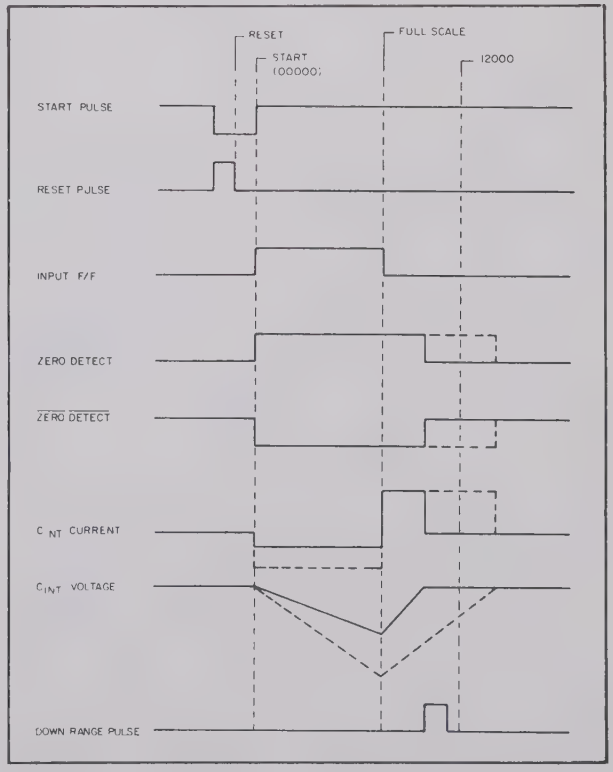


Figure 4-18. Down-Range Pulse

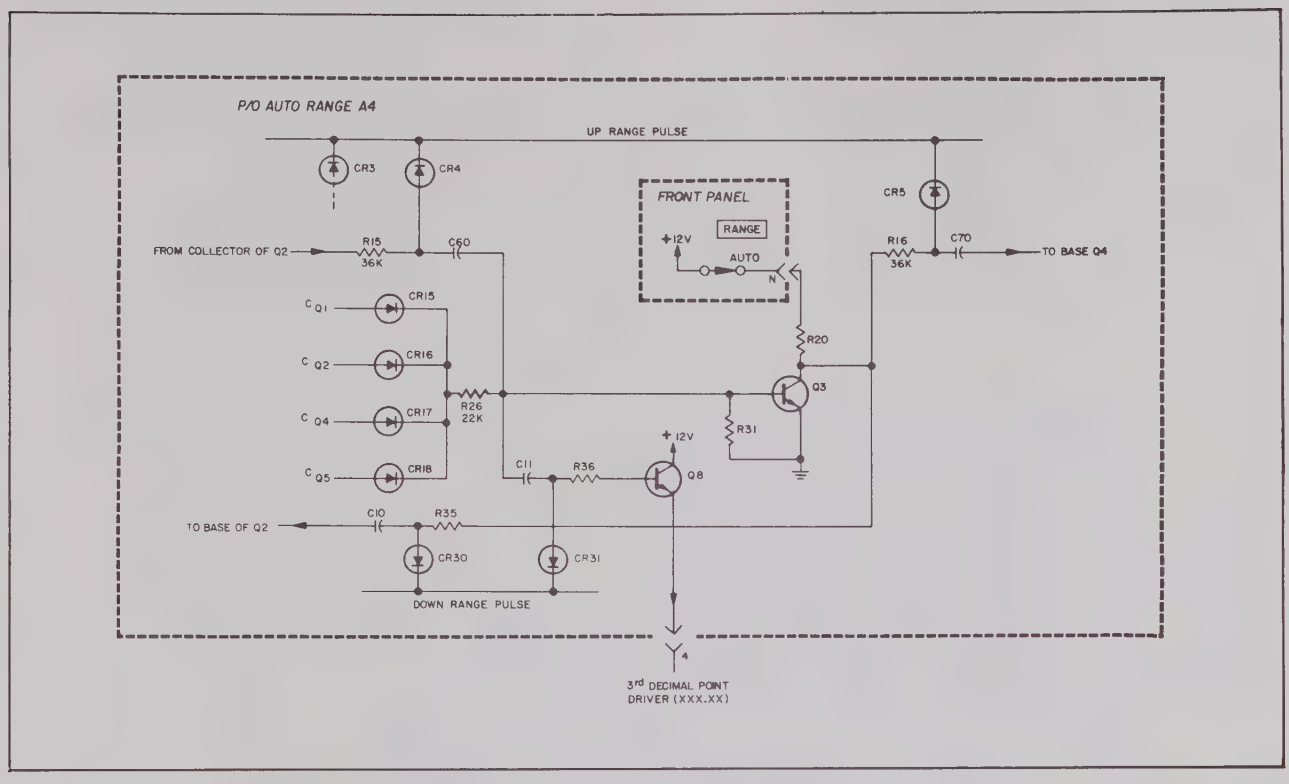


Figure 4-19. Ring Counter - Third Stage

Ring Counter

Operation of the ring counter is such that at any one time, all stages in the counter are on except one; it is held off. Assume an initial condition with A4Q3 off (refer to figure 4-19). In this condition, decimal point driver A4Q8 is turned on and the visual range indication is given as XXX.XX. The positive voltage at the collector of A4Q3 deposits a charge on A4C70 and A4C10. A4C70 is used in up ranging; A4C10 in down ranging. The collectors of transistors A4Q1, A4Q2, A4Q4 and A4Q5 are held to ground when A4Q4 is off.

When an up range pulse (the negative going trailing edge is used to trigger the counter) is applied to the ring counter, the negative pulse is passed by steering diodes A4CR3, C4CR4, A4CR5, A4CR6 and transmitted across the input capacitors to the bases of their respective transistors. Momentarily all of the stages are driven off. Due to the preset charge on A4C70, A4Q4 is driven further off than the other stages. A4Q3 is driven on as the voltage rise at the collector of A4Q4 is transmitted via A4CR17 to the base of A4Q3. Similar action also holds all of the other stages on. The new decimal point location is XXX.X.

POWER SUPPLY REGULATOR A12

Power supply voltages are obtained from regulators mounted on board A12. Supply voltages are +30 V, +12 V, ±25 V, +4 V and ±22 V floating.

±22 Volt Floating Supply

The floating ±22 V supply is used with the input amplifier exclusively. The ground reference of the supply is isolated from the main circuit common (LO). Regulation of the –22 V output is controlled by series regulator A12Q19. See figure 4-20. Reference is established by zener diode A12CR10. The –22 V output is sensed across resistors A12R40 through A12R43, and output variation is detected at the base of A12Q18. The emitter of A12Q18 is held at a fixed reference potential by zener diode A12CR10. The output at the collector of A12Q18 controls series regulator A12Q19. Regulation is accomplished as follows: An increase in current load causes a tendency to lower the output voltage. The slight voltage drop is sensed at the base of A12Q18 making it conduct less. This allows more base current to flow into Q19 causing it to conduct harder to com-

pensate for the voltage drop. Resistor A12R33 shares the load current with series regulator A12Q19. Transistor A12Q20 and resistor A12R39 act together to provide short circuit protection. Output current flows through A12R39 and when the current becomes too large, the drop across A12R39 is sufficient to turn A12-Q20 on. This turns the series regulator off. Capacitor A12C8 acts as a filter to reduce ripple at the output of the supply. Resistor A12R32 and A12CR11 provide a load path for A12Q18. Capacitor A12C6 reduces ripple at the input of the regulator. The jumpers across A12R41 and A12R42 are factory preset to set the output to -22 V.

The +22 V circuit is referenced to the -22 V supply and operates in a similar manner.

+30 V, +12 V, ±25 V Power Supplies

The +30 V supply is capable of delivering 30 mA and its main function is to provide relay driving power. Resistor A12R7 and capacitor A12C4 comprise a simple filter network to reduce ripple in the +30 V output. See figure 5-28. The +12 V and ±25 V outputs are used to provide circuit levels for V_{CC}, etc. The +12 V supply employs series regulator A12Q14 and reference zener diode A12CR4 to accomplish regulation. Diodes A12-CR5, A12CR6, A12CR7 provide additional voltage offset to accomplish the +12 V output. Regulation of the +25 V supply is reference to the -25 V output.

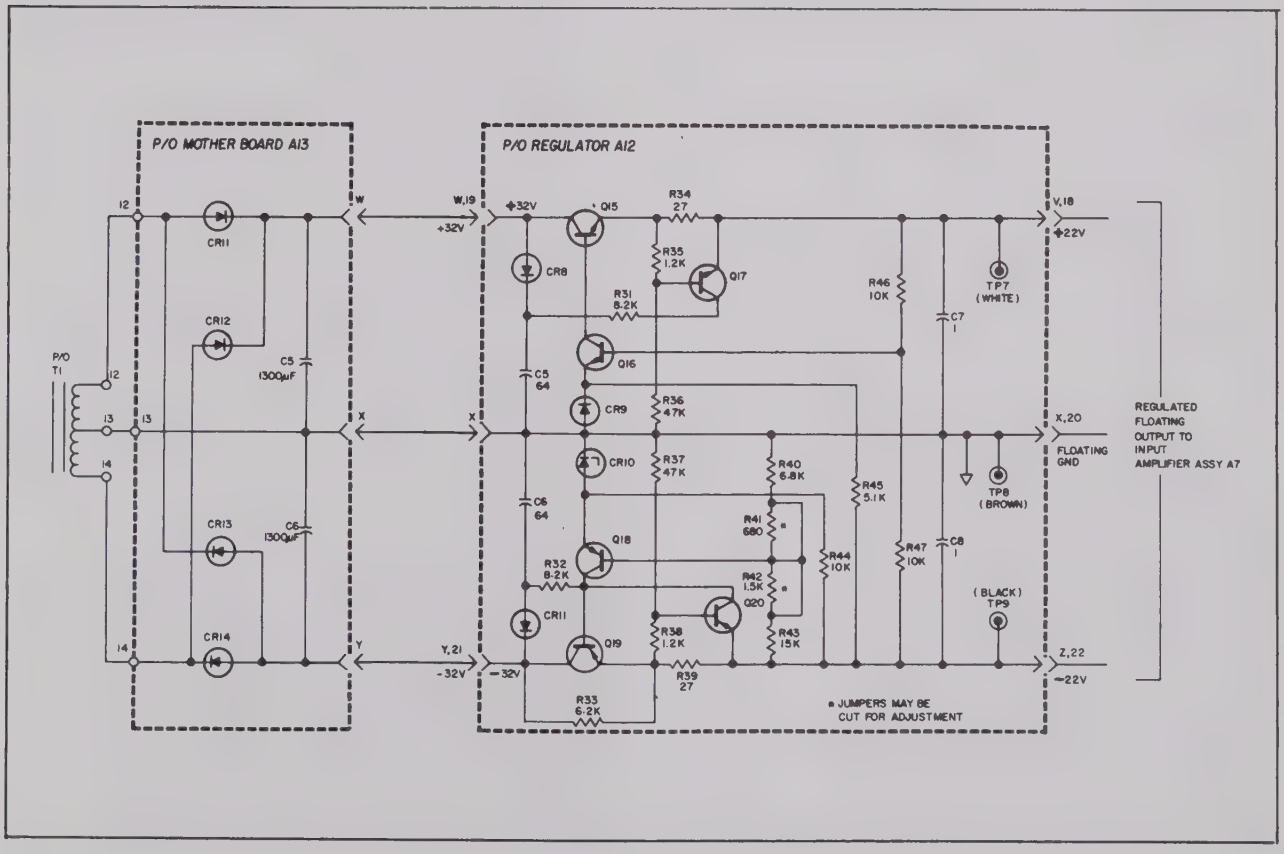


Figure 4-20. ± 22V Floating Supply

Table 5-1. Required Test Equipment

Instrument Type	Purpose	Critical Specifications	Recommended Instrument
DC Voltage Standard	DC voltage alignment and calibration.	Accuracy: ±0.003% Range: 0.1 μV to 1000 V	Fluke Model 332A
Resistance Standard	Resistance alignment and calibration.	Accuracy: ±0.01% Range: 0.1 Ω to 12 MΩ	ESI DB 877
AC Voltage Source	Provide AC test voltage at low distortion.	Stability: ±0.02% Distortion: < 0.05% Output: < ADJ to 1000 V 50 Hz to 100 kHz	Optimation, Inc. Model AC-104A and HP 331A (Distortion Analyzer)
Ratio Transformer	Provide low-level AC voltage for linearity test.	Accuracy: 0.01% to 20 kHz	Gertch Model RT13 or Optimation, Inc. Model AC-104A
AC Thermal Transfer	Compare rms value of sinewave voltages from AC source with DC output from DC voltage standard.	Voltage Range: 0.25 V to 1000 V Frequency Range: 50 Hz to 100 kHz AC-DC Calibration: ±0.01%	Fluke Model 540B
DC Current Standard	Provide DC current for alignment and calibration.	Current Range: 0.1 μA to 1 A Accuracy: +0.02%	Fluke Model 382A
DC Current Meter	Measure DVM Offset Current.	Current Range: 10 pA to 1 mA Accuracy: 2%	HP Model 425A
Voltmeter	Power Supply Checks	Range: 1000 V Accuracy: 0.2% Input Resistance: 10 MΩ	Fairchild Model 7100A
Oscilloscope	Ripple measurements.	Passband: DC to 300 kc Sensitivity: 1 mV/cm	Tektronix 540 Series

Section V
Maintenance

INTRODUCTION

This section contains calibration, maintenance, and troubleshooting information for the Model 7000A. Also included is a list of test equipment required for the procedures outlined in the section.

TEST EQUIPMENT REQUIRED

Table 5-1 lists the test equipment required for performance tests, troubleshooting, and adjustment of the instrument. If the recommended equipment is not available, equipment with equivalent specifications may be substituted.

In procedures that involve accurate DC voltage or resistance measurements, care must be taken to ensure consistent results. Working standards should be referred to primary standards on a regular basis. Particular care should be observed with resistance standards that are subject to long-term drift due to aging.

PERFORMANCE CHECK

The performance check outlined in the following paragraphs will verify the specifications of the Model 7000A. It can be used upon receipt of a new instrument, for routine preventive maintenance, and following repair of the instrument. The Model 7000A under test may not have all of the measurement options. In this case, check only those modes pertinent to the unit under test.

DC Voltage Measurement Accuracy

To check the accuracy of DC voltage readout proceed as follows:

a. Make following initial settings on Model 7000A.

FUNCTION	V DC
RANGE	1
PWR ON	on

b. Set output of DC Voltage Standard to zero.

c. Connect HI and LO INPUT terminals on Model 7000A to positive (+) and negative (–) output terminals respectively on DC Voltage Standard.

d. Check readout at each Voltage Standard output setting listed in table 5-2. In each case readout should be within tolerance given.

e. Reduce DC Voltage Standard output to zero and disconnect test equipment from Model 7000A.

NOTE

If the instrument fails to meet the performance standards at any time, proceed to the appropriate calibration and alignment procedure to correct the malfunction.

Table 5-2. DC Voltage Measurement Accuracy at 25°C

7000A Function & Range	DC Voltage Standard (Volts)	7000A Readout Limits	
		Maximum	Minimum
V DC 1	0.0000	±0.0001	±0.0001
	±0.3000	±0.3001	±0.2999
	±0.8000	±0.8002	±0.7998
	±1.1000	±1.1002	±1.0998
V DC 10	±00.000	±00.001	±00.001
	±03.000	±03.002	±02.998
	±08.000	±08.002	±07.998
	±11.000	±11.002	±10.998
V DC 100	±000.00	±000.01	±000.01
	±030.00	±030.01	±029.99
	±080.00	±080.02	±079.98
	±110.00	±110.02	±109.98
V DC 1000	±0000.0	±0000.1	±0000.1
	±0300.0	±0300.1	±0299.9
	±0800.0	±0800.3	±0799.7
	±1000.0	±1000.2	±0999.8

DC mV Measurement Accuracy

To check accuracy of DC mV readout, proceed as follows:

a. Make following initial settings on Model 7000A.

FUNCTION . . . . . mV
RANGE . . . . . 100 mV
PWR ON . . . . . on

CAUTION

Do not apply voltages in excess of 300 V to the Model 7000A. Damage to the instrument may result.

b. Set output of DC Voltage Standard to zero.

c. Connect HI and LO terminals on Model 7000A to positive (+) and negative (–) output terminals respectively on DC Voltage Standard.

d. Check readout at each DC Voltage Standard output setting listed in table 5-3. In each case readout should be within tolerance given.

e. When tests are complete, reduce DC Voltage Standard to zero and disconnect from Model 7000A.

Table 5-3. DC mV Measurement Accuracy at 25°C

7000A Function & Range	DC Voltage Standard mV	7000A Readout Limits	
		Max.	Min.
mV	000.00	±000.02	±000.02
100 mV	±001.00	±001.02	±000.98
	±010.00	±010.02	±009.98
	±100.00	±100.03	±099.97

Resistance Measurement Accuracy

To verify resistance readout accuracy, use the following procedure:

a. Make following initial settings on Model 7000A.

FUNCTION . . . . . kΩ
RANGE 1
PWR ON . . . . . on

b. Set standard resistance to 1 kΩ.

c. Connect HI and LO INPUT terminals on Model 7000A to output terminals on Resistance Standard.

d. Check readout accuracy at each Resistance Standard setting listed in table 5-4. In each case readout should be within tolerance given.

e. Disconnect Resistance Standard from Model 7000A.

Table 5-4. Resistance Measurement Accuracy Check at 25°C

7000A Function & Range	Resistance Standard (kΩ)	7000A Readout Limits	
		Max.	Min.
kΩ 1	0.0000	0.0002	
	0.2500	0.2503	0.2497
	0.6000	0.6005	0.5995
	1.1000	1.1008	1.0992
kΩ 10	1.100	01.103	01.097
	2.500	02.503	02.497
	6.000	06.005	05.995
	11.000	11.008	10.992
kΩ 100	11.00	011.03	010.97
	25.00	025.03	024.97
	60.00	060.05	059.95
	110.00	110.08	109.92
kΩ 1000	110.0	0110.4	0109.6
	250.0	0250.6	0249.4
	600.0	0600.9	0599.1
	1100.0	1101.4	1098.6
MΩ 10	1100	01107	01093
	2500	02510	02490
	6000	06017	05983
	10000	10025	09975

AC Voltage Measurement Accuracy

Use the following procedure to verify AC voltage readout accuracy. See figure 5-1 for test setup.

a. Make following initial settings on Model 7000A.

FUNCTION . . . . . V AC
RANGE . . . . . 1 V
PWR ON . . . . . on

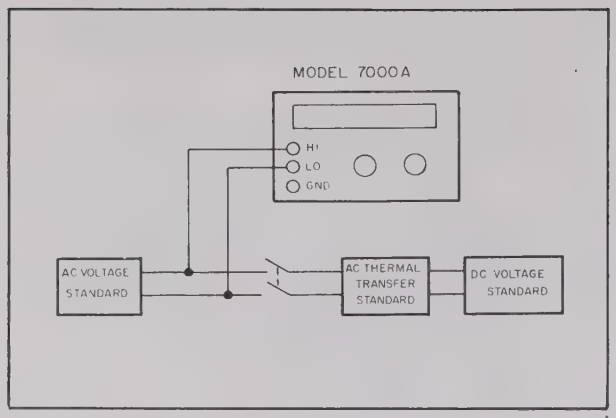


Figure 5-1. Test Set-Up, AC Measurement Accuracy Check

b. Disconnect all equipment from AC Thermal Standard except DC Voltage Standard.

c. Set DC Voltage Standard to 1.0000 V (amplitude of desired rms test voltage.

d. Adjust meter on AC Thermal Transfer until a null is indicated.

e. Connect AC Voltage Standard to second set of input terminals on Thermal Transfer Standard. Set AC Standard for 60 Hz output. Adjust AC Standard amplitude until meter on Thermal Standard Transfer again nulls. Amplitude of AC test voltage is now 1 V rms.

CAUTION

In the following steps do not exceed maximum input voltage ratings. Damage to the Model 7000A may result.

Freq. Range	Max. Input Voltage
50 Hz to 10 kHz	750 V
10 kHz to 30 kHz	500 V
30 kHz to 100 kHz	350 V

f. Connect HI and LO INPUT terminals on Model 7000A across output of AC Voltage Standard.

g. Check readout at each AC Voltage Standard level and frequency setting listed in table 5-5. In each case readout should be within tolerance given.

NOTE

Each time AC Voltage Standard settings are changed, check output against AC Thermal Standard as previously described.

h. At completion of tests, disconnect all test equipment.

Table 5-5. AC Voltage Measurement Accuracy at 25°C °C

7000A Function & Range	AC Voltage Standard		7000A Readout Limits	
	Freq.	V rms	Max.	Min.
V AC 1	50 Hz	1.0000 V	1.0012	0.9988
	400 Hz		1.0012	0.9988
	1 kHz		1.0012	0.9988
	5 kHz		1.0012	0.9988
	10 kHz		1.0012	0.9988
	30 kHz		1.0030	0.9970
	100 kHz		1.0120	0.9880
V AC 10	50 Hz	10.000 V	10.012	09.988
	400 Hz		10.012	09.988
	1 kHz		10.012	09.988
	5 kHz		10.012	09.988
	10 kHz		10.012	09.988
	30 kHz		10.030	09.970
	100 kHz		10.120	09.880
V AC 100	50 Hz	100.00 V	100.17	099.83
	400 Hz		100.17	099.83
	1 Hz		100.17	099.83
	5 Hz		100.17	099.83
	10 kHz		100.17	099.83
	30 kHz		100.35	099.65
	100 kHz		101.25	098.75
V AC 1000	50 Hz	750.0 V	0754.7	0745.3
	400 Hz	750.0 V	0754.7	0745.3
	1 kHz	750.0 V	0754.7	0745.3
	10 kHz	750.0 V	0754.7	0745.3
	30 kHz	500.0 V	0504.2	0495.8
	100 kHz	350.0 V	0357.2	0342.8

DC Current Measurement Accuracy

Use following procedure to verify DC current readout accuracy:

a. Make following initial settings on Model 7000A.

FUNCTION . . . . . MA DC
RANGE 1
PWR ON . . . . . on

CAUTION

Do not apply currents in excess of 2 amps to the Model 7000A. Damage to the instrument may result.

b. Set current output from the DC Current Standard to zero. Connect Current Standard output terminals to HI and LO INPUT terminals on Model 7000A.

c. Check accuracy at each setting of DC Current Standard listed in table 5-6. In each case readout should be within tolerance given.

d. Disconnect Current Source from Model 7000A.

Table 5-6. DC Current Measurement Accuracy at 25°C

7000A Function & Range	DC Current Standard (mA)	7000 Readout Limits	
		Max.	Min.
mA 1	0.0000	±0.0002	±0.0002
	±0.2500	±0.2506	±0.2494
	±0.6000	±0.6010	±0.5990
	±1.1000	±1.1017	±1.0983
mA 10	± 1.100	±01.104	±01.096
	± 2.500	±02.506	±02.494
	± 6.000	±06.010	±05.990
	±11.000	±11.017	±10.983
mA 100	± 11.00	±011.04	±010.96
	± 25.00	±025.06	±024.94
	± 60.00	±060.10	±059.90
	±110.00	±110.17	±109.83
mA 1000	± 110.0	±0110.4	±0109.6
	± 250.0	±0250.6	±0249.4
	± 600.0	±0601.0	±0599.0
	±1000.0	±1001.5	±0998.5

Automatic Ranging

Check operation of the automatic ranging circuitry as follows:

a. Make following initial settings on Model 7000A.

FUNCTION . . . . . V DC
RANGE . . . . . AUTO
PWR ON . . . . . on

b. Set output of DC Voltage Standard to zero.

c. Connect HI and LO INPUT terminals on Model 7000A to output terminals on DC Voltage Standard.

d. Set DC Voltage Standard to 1.19999 V. The Model 7000A should read on 1 V scale.

e. Set DC Voltage Standard to 1.2000 V. The Model 7000A readout should up range to 10 V range.

f. Set DC Voltage Standard to 01.081 V. Instrument should remain in 10 V range.

g. Set DC Voltage Standard to 01.0790 V. Instrument should down range to 1 V range.

h. Check remaining ranges using voltages given in table 5-7. Note that instrument changes range at voltage levels listed.

Table 5-7. Auto-Ranging Limits

Range	Range Change Voltage			
	Up Min.	Up Max.	Down Min.	Down Max.
1	1.2000	1.2009	—	—
10	12.000	12.009	01.080	01.071
100	120.00	120.09	010.80	010.71
1000	—	—	0108.0	0107.1

Overload Indicator

To check operation of the OVERLOAD indicator use following procedure:

a. Make following initial settings on Model 7000A.

FUNCTION . . . . . V DC
RANGE 1
PWR ON . . . . . on

b. Set output of DC Voltage Standard to zero.

c. Connect HI and LO INPUT terminals of Model 7000A to output terminals on DC Voltage Standard.

d. Increase output of DC Voltage Standard to 1.1999. OVERLOAD indicator should NOT light.

e. Momentarily increase DC voltage to 1.2000. OVERLOAD indicator should start blinking. Decrease DC voltage to zero.

f. Disconnect DC Voltage Standard from Model 7000A.

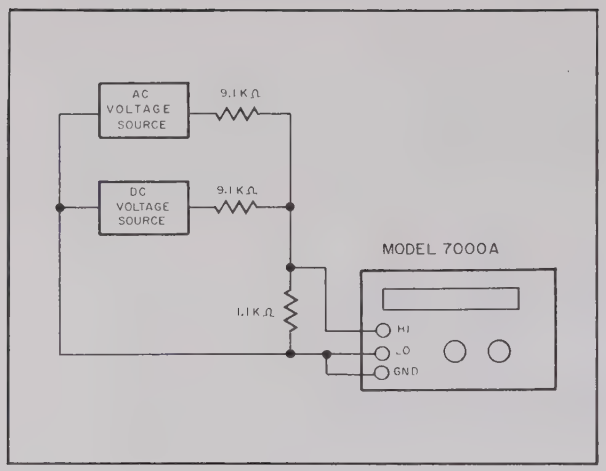


Figure 5-2. Test Circuit, Normal Mode Rejection Test

Normal Mode Rejection

To check the normal mode rejection capability of Model 7000A, proceed as follows:

a. Connect Model 7000A in test setup shown in figure 5-2. Make following initial settings on Model 7000A.

FUNCTION . . . . . V DC
RANGE 1
PWR ON . . . . . on

b. Set AC Voltage Standard to zero.

c. Adjust DC Voltage Standard to give a stable 0.5000 V DC readout on Model 7000A.

d. Increase AC voltage (60 Hz) level until one digit change (or jitter) takes place. Note AC voltage reading.

e. Check normal mode rejection at each of the frequencies listed in table 5-7.

Table 5-8. Normal Mode Rejection Limits

Frequency	Minimum AC Voltage
60 Hz	35 mV peak or 23 mV rms
120 Hz	100 mV peak or 70.7 mV rms
400 Hz	316 mV peak or 224 mV rms

PERIODIC MAINTENANCE

The Model 7000A requires a minimum of periodic maintenance. If maintenance is performed on a regular basis, the paragraphs below suggest a routine to follow.

a. Remove top and bottom covers from instrument. Inspect the chassis and mounted components for damage, signs of overheating, etc. Remove circuit boards and inspect for damage or evidence of component failure. Using low pressure dry compressed air, blow out any dust accumulation.

b. Rotate front panel controls through full range, noting any binding or rough action.

c. Following inspection, replace all circuit boards and covers. Carry out performance check beginning on page 5-1.

CALIBRATION PROCEDURE

The calibration and alignment procedure that follows can be used after field installation of a measurement option, for routine preventive maintenance, and following repair. The multimeter may not have all options fitted. In this case, follow only those portions of the calibration procedure pertinent to the unit under test.

DC Power Supply

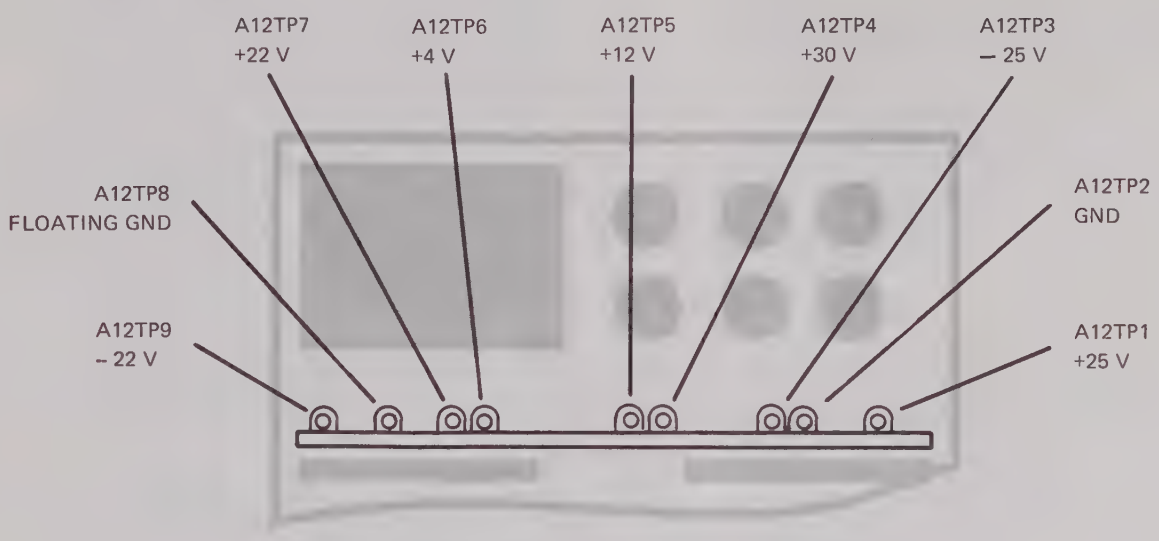
To check instrument DC Voltage proceed as follows:

a. Remove top cover from instrument and locate power supply regulator board A12. See figure 5-3.

b. Connect instrument to AC power source and set front panel PWR ON switch to on.

c. Connect digital voltmeter between TP4 (+30 V) and TP2 (GND). Check that readout is between +28 V and +40 V. Check that ripple oscilloscope does not exceed 300 mV rms.

d. Consult figure 5-3 and measure remainder of voltage outputs listed in table. Make adjustments where necessary.



Step	Test Points	Voltage Limits	Adjustment	Max. Ripple
1	TP4(+) TP2	+28 V to +40 V	Nonregulated supply, no adjustment.	⩽ 300 mV rms
2	TP5(+) TP2	+8 V to +12 V	Semiregulated supply, no adjustment.	⩽ 100 mV rms
3	TP3(–) TP2	–24.5 V to –25.5 V	Remove jumper across A12-R17 to increase voltage. Remove jumper across A12-R16 to decrease voltage.	⩽ 5 mV rms
4	TP1(+) TP2	+24.0 V to +26.0 V	No adjustment necessary.	⩽ 5 mV rms
5	TP6(+) TP2	+3.6 V to +4.0 V	Remove jumper across A12-R28 to increase voltage. Remove jumper across A12-R29 to decrease voltage.	⩽ 50 mV rms
6	TP9(–) TP8	–24.0 V to –27.0 V	Remove jumper across A12-R42 to increase voltage. Remove jumper across A12-R41 to decrease voltage.	⩽ 5 mV rms
7	TP7(+) TP8	+23.5 V to +27.5 V	No adjustment necessary.	⩽ 5 mV rms
8	A12-1(+) A12-3	+170 V to +230 V	No adjustment necessary	⩽ 3 V rms

Figure 5-3. · Power Supply Checkout and Adjustment

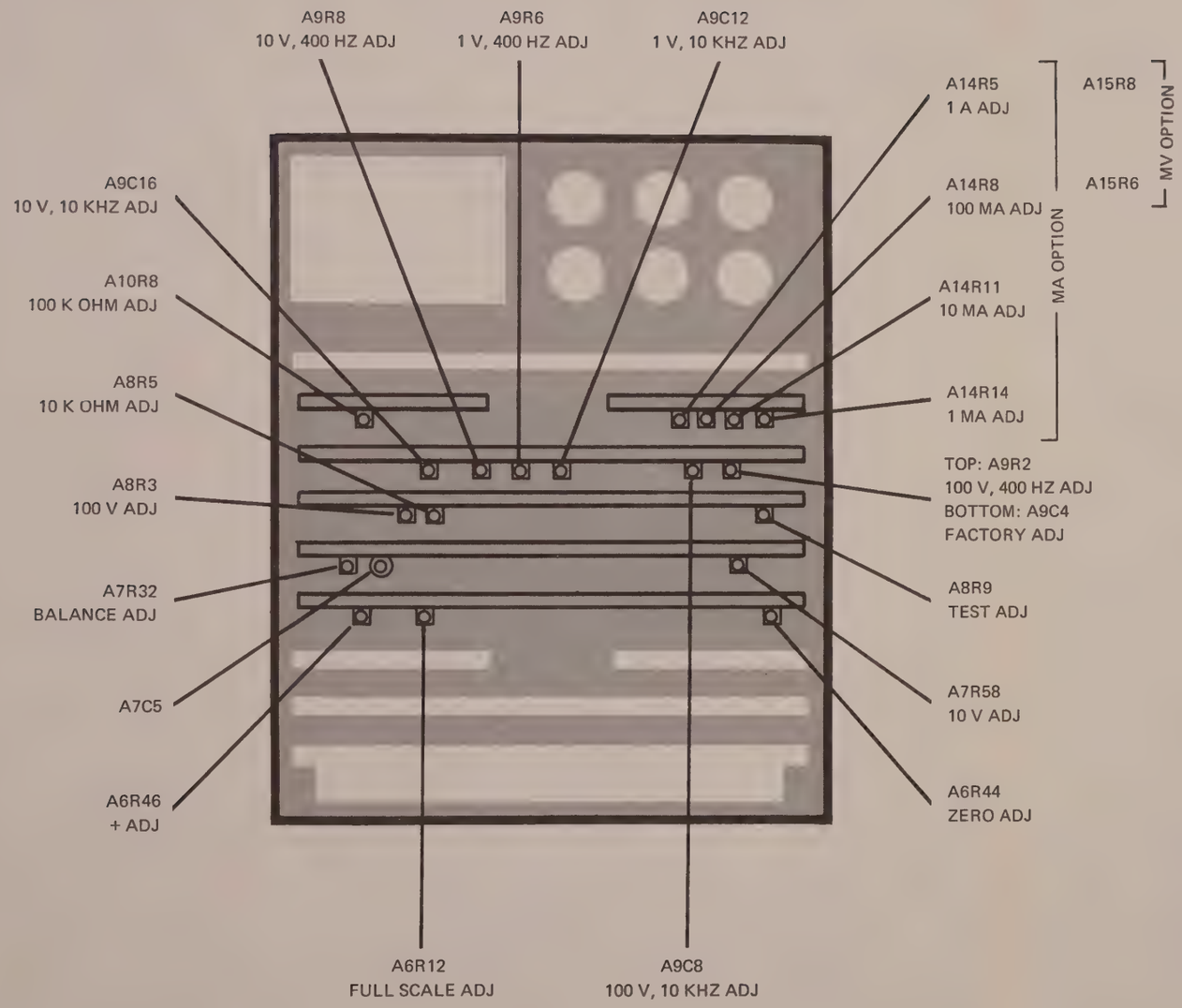
CALIBRATION

The calibration procedure for the Model 7000A is contained in figure 5-4. Perform steps 1 through 11 to align the DC volts measurement circuitry, and then the steps applicable to the measurement options fitted in the instrument.

PARTS LOCATION AND SCHEMATICS

Figures 5-5. through 5-32 show (a) location of all electronic components installed in the Model 7000A and (b) detailed schematics of assemblies.

NOTES



Step	Model 7000A		Input	
	Function	Range		
1	V DC	1	±0.0030 V	Adjust A7-R32 for symmetrical readout. The DRO may not be ±0.0030 V.
2	V DC	1	shorted	Adjust A6-R46 (± adjust) for uncertain plus-minus indication, then favor the plus by ½ turn (clockwise).
3	V DC	1	+0.0010 V	Adjust A6-R44 (zero adjust) for DRO of +0.0010.
4	V DC	1	-----	With an ammeter between the Hi and Lo input terminals, adjust A7-C5 for ⩽±50 pA or minimum offset current.
5	V DC	1	±0.0030 V	Adjust A7-R32 for symmetrical readout. NOTE: Before proceeding: Repeat steps 4 and 5 until the offset current is less than 50 pA and the symmetry is set.
6	V DC	1	±0.00305 V	Adjust A6-R44 and A7-R32 for DRO that blinks between ±0.0030 and ±0.0031.
7	V DC	1	-1.0000 V	Adjust A6-R12 for full scale DRO of -1.0000 V.
8	V DC	1	+1.0000 V	DRO shall be +1.0000 V ± 1 digit.
9	V DC	10	-10.000 V	Adjust A7-R58 for readout of -10.000 V.
10	V DC	10	+10.000 V	Readout shall be +10.000 V ± 1 digit.
11	V DC	100	-100.00 V	Adjust A8-R3 for readout of -100.00 V.
12	V DC	100	+100.00 V	Readout shall be +100.00 V ± 1 digit.
13	V DC	1000	±1000.0 V	Readout shall be ±1000.0 V ± 2 digits.
14	TEST	10	NONE	Adjust A8-R9 for readout of 01.000.
1	mV	100 mV	shorted	Adjust mV zero full counter clockwise. Front Panel.
2	mV	100 mV	shorted	Adjust A15-R6 for -000.04 mV.
3	mV	100 mV	shorted	Adjust mV zero for +000.00 mV.
4	mV	100 mV	+100.00 mV	Adjust A15-R8 for +100.00 mV.
5	mV	100 mV	-----	With an ammeter between the Hi and Lo input terminals, measure the input current. Should be less than 100 pA.
1	kΩ	100	100.00 kΩ	Adjust A10-R8 for readout of 100.00 kΩ.
2	kΩ	10	10.000 kΩ	Adjust A8-R5 for readout of 10.000 kΩ.
1	mA	1	+1.0000 mA	Adjust A14-R14 for readout of +1.0000 mA.
2	mA	10	+10.000 mA	Adjust A14-R11 for readout of +10.000 mA.
3	mA	100	+100.00 mA	Adjust A14-R8 for readout of +100.00 mA.
4	mA	1000	+1000.0 mA	Adjust A14-R5 for readout of +1000.0 mA.
1	V AC	1	1.0000 V 400 Hz	Adjust A9-R6 for readout of 1.0000 V AC.
2	V AC	1	1.0000 V 10 kHz	Adjust A9-C12 for readout of 1.0000 V AC.
3	V AC	10	10.000 V 400 Hz	Adjust A9-R8 for readout of 10.000 V AC.
4	V AC	10	10.000 V 80 kHz	Adjust A9-C16 for readout of 10.000 V AC.
5	V AC	100	100.00 V 400 Hz	Adjust A9-R2 for readout of 100.00 V AC.
6	V AC	100	100.00 V 80 kHz	Adjust A9-C8 for readout of 100.00 V AC.

Figure 5-4. Model 7000A Alignment Procedure

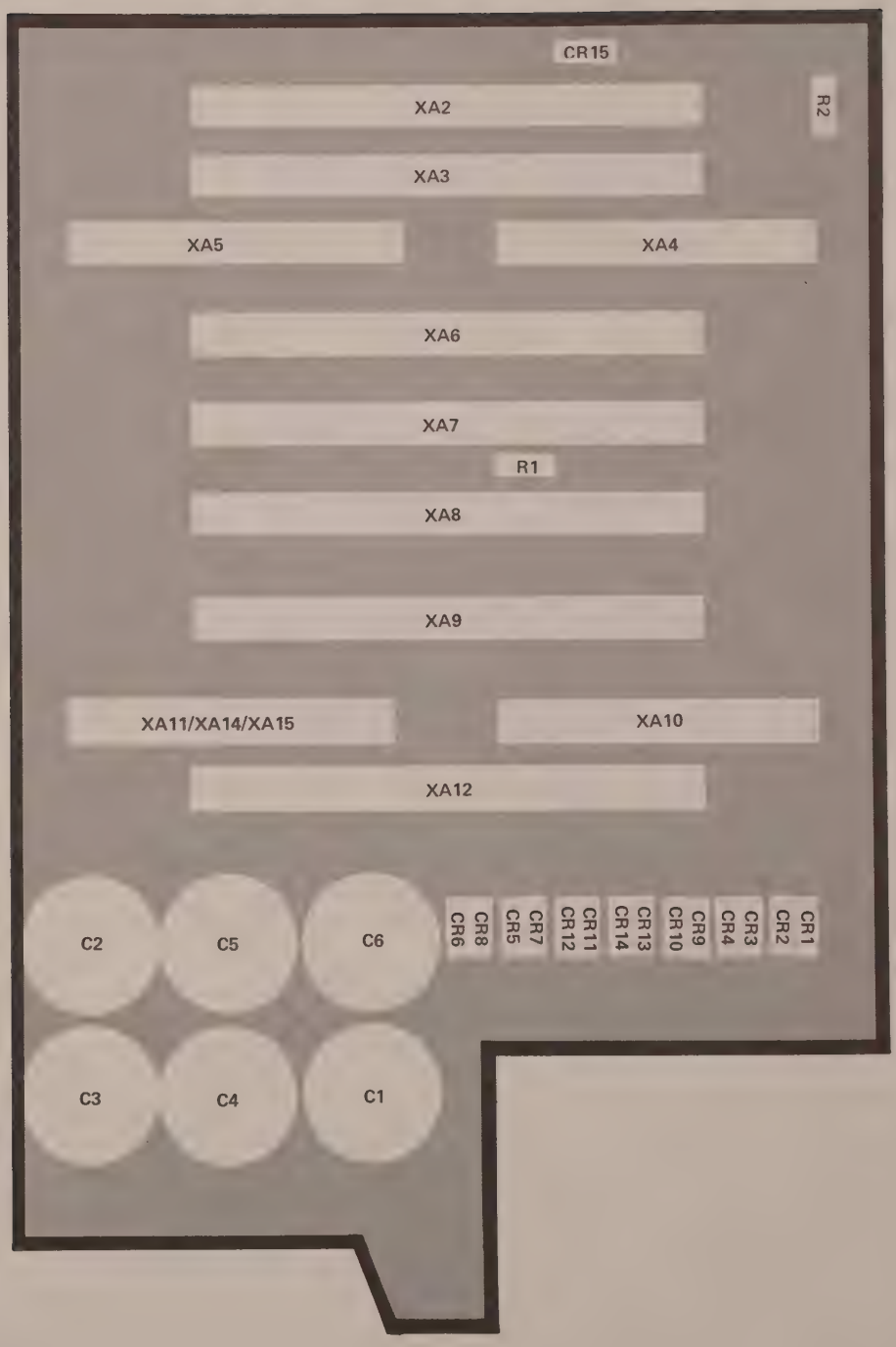


Figure 5-5. Component Location, Mother Board A13

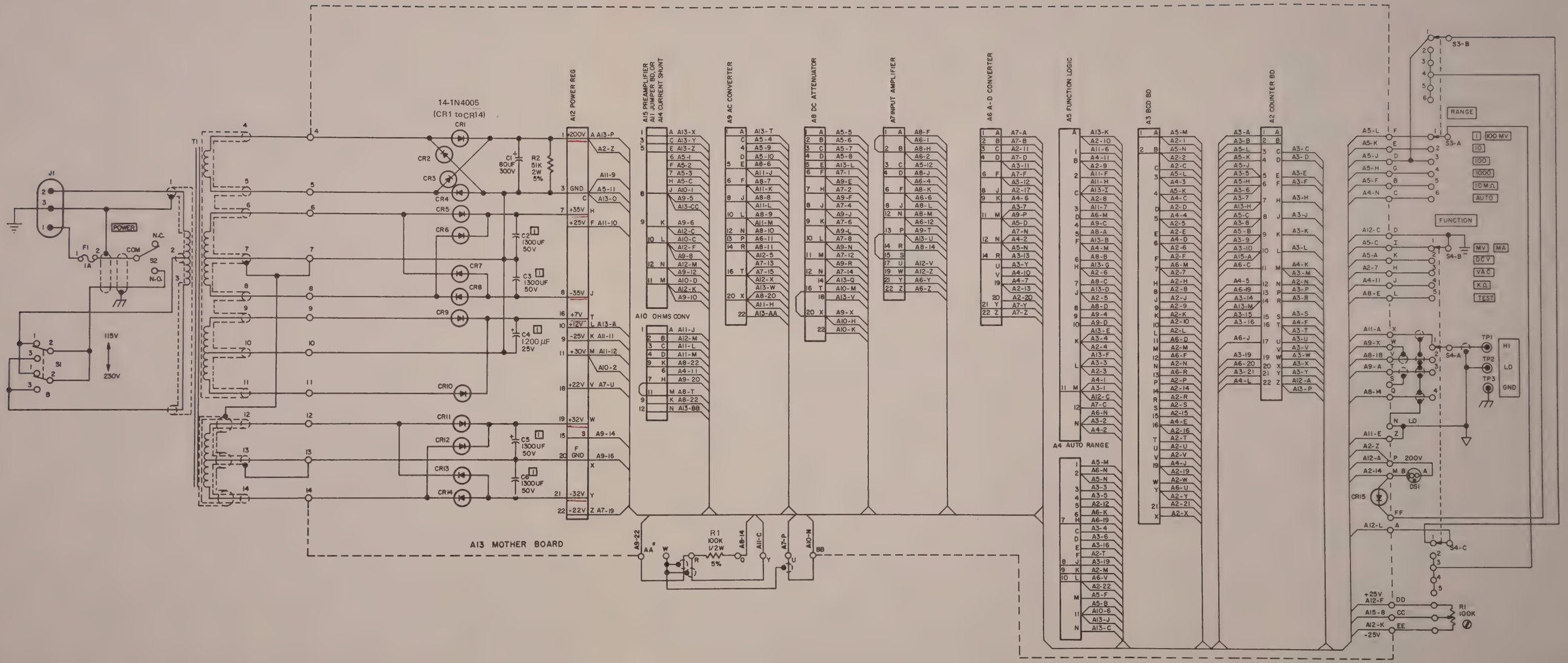


Figure 5-6. Interconnect Diagram, Model 7000A

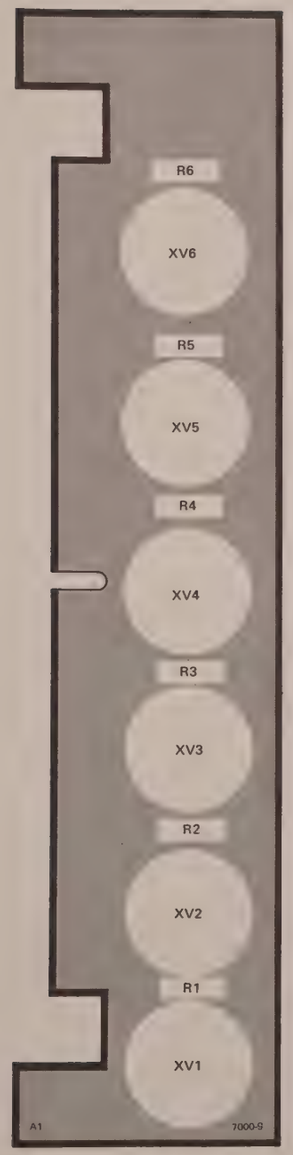


Figure 5-7. Component Location, Readout Assembly A1

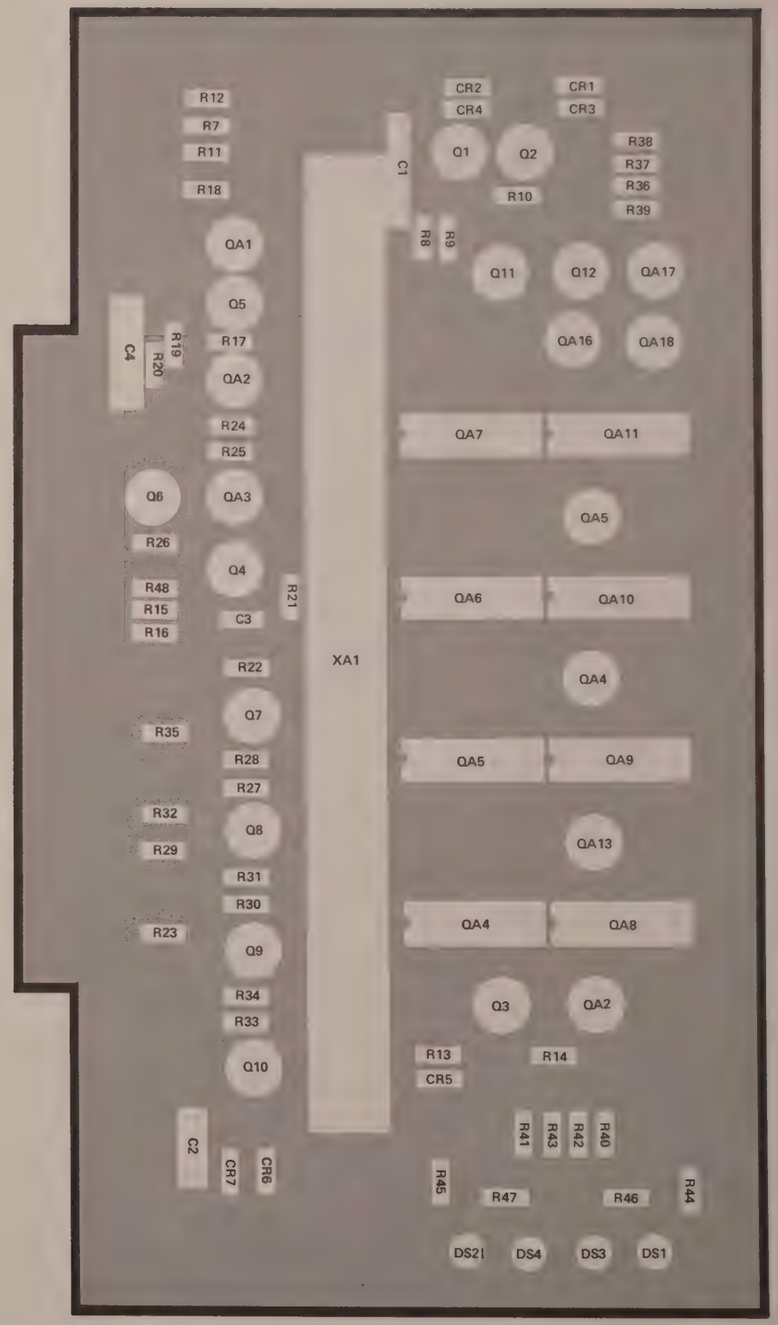
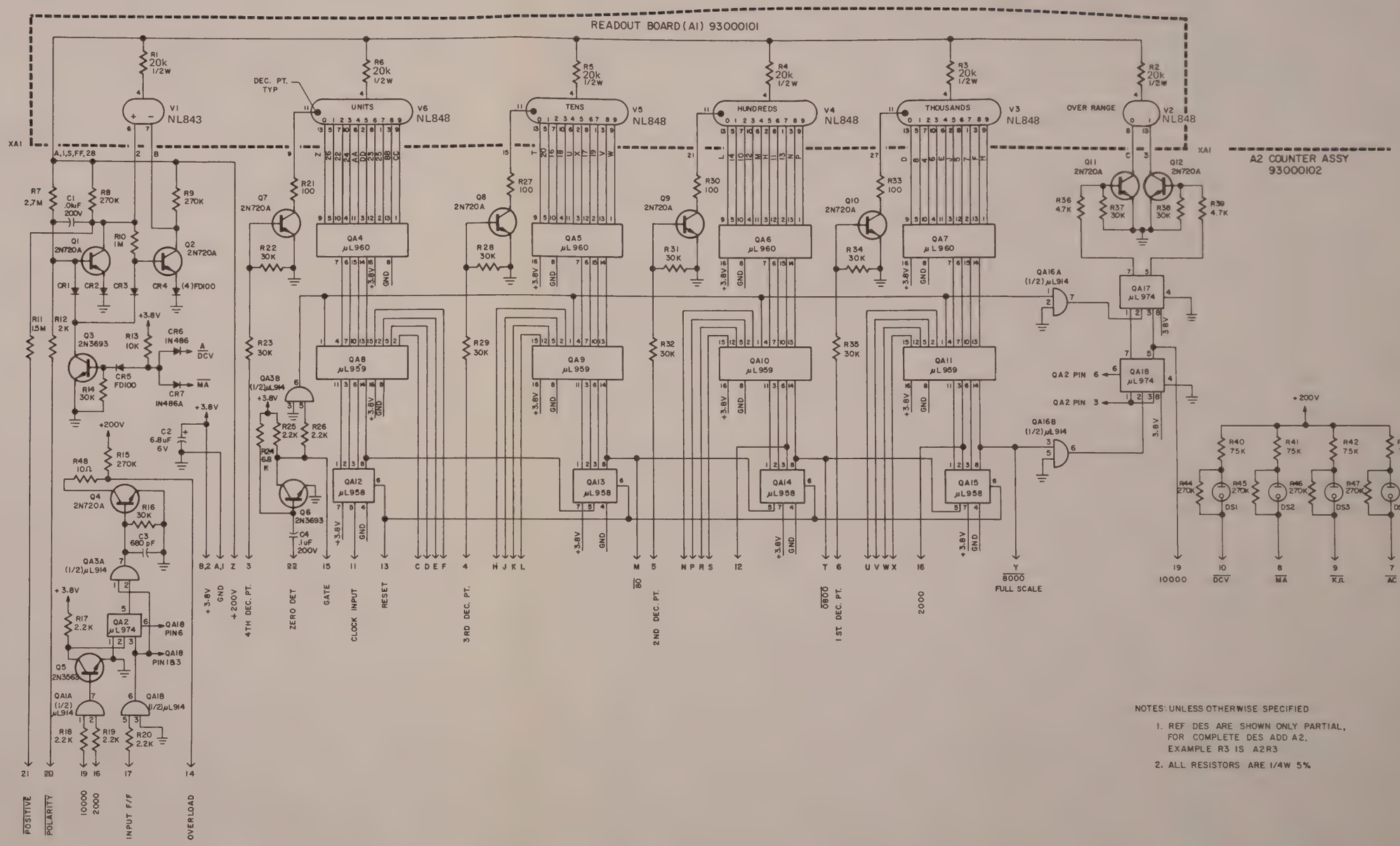


Figure 5-8. Component Location, Counter Assembly A2



NOTES: UNLESS OTHERWISE SPECIFIED

1. REF DES ARE SHOWN ONLY PARTIAL, FOR COMPLETE DES ADD A2. EXAMPLE R3 IS A2R3
2. ALL RESISTORS ARE 1/4W 5%

Figure 5-9. Schematic, Readout Assembly A1 and Counter Assembly A2

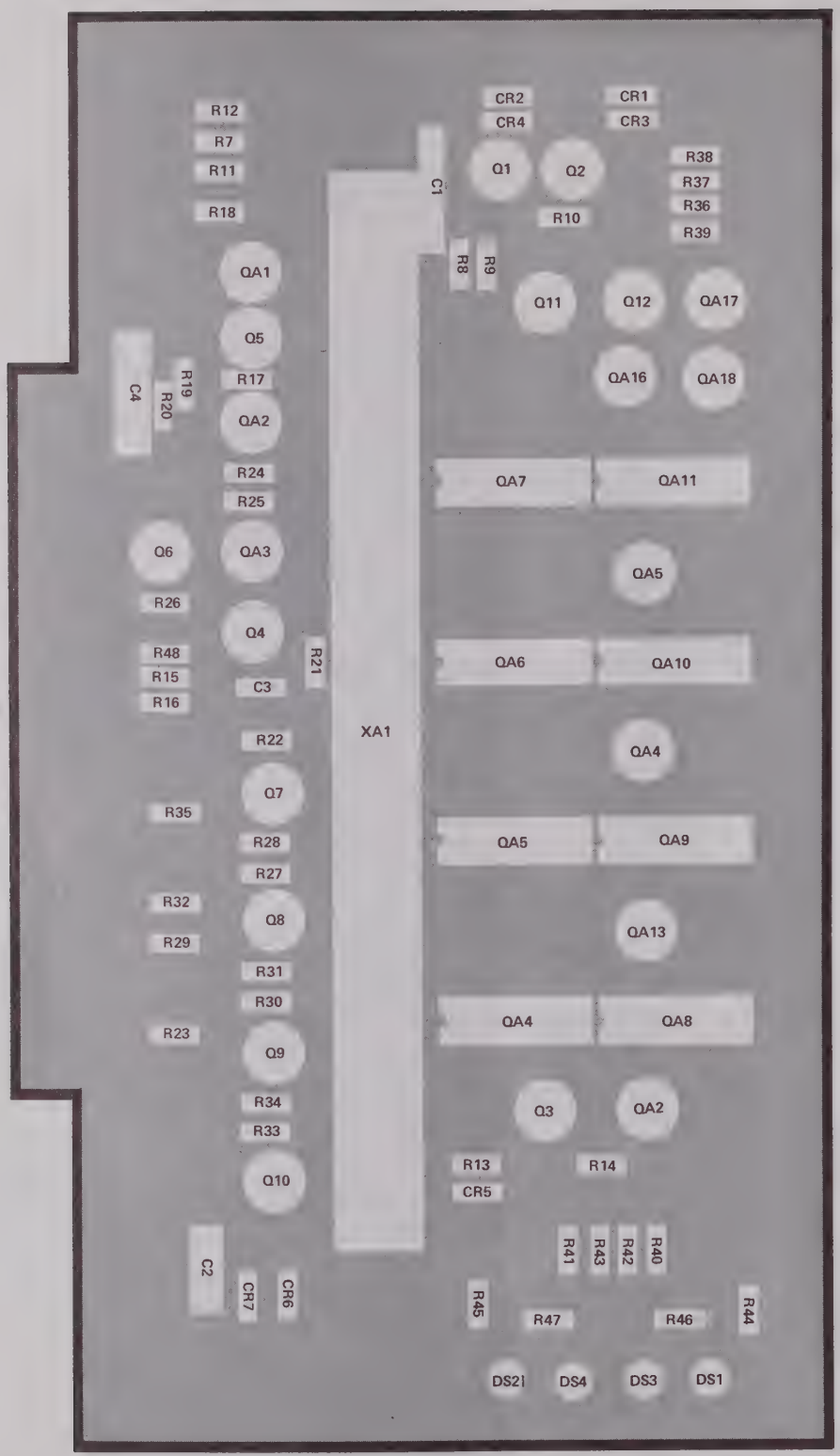


Figure 5-8. Component Location, Counter Assembly A2

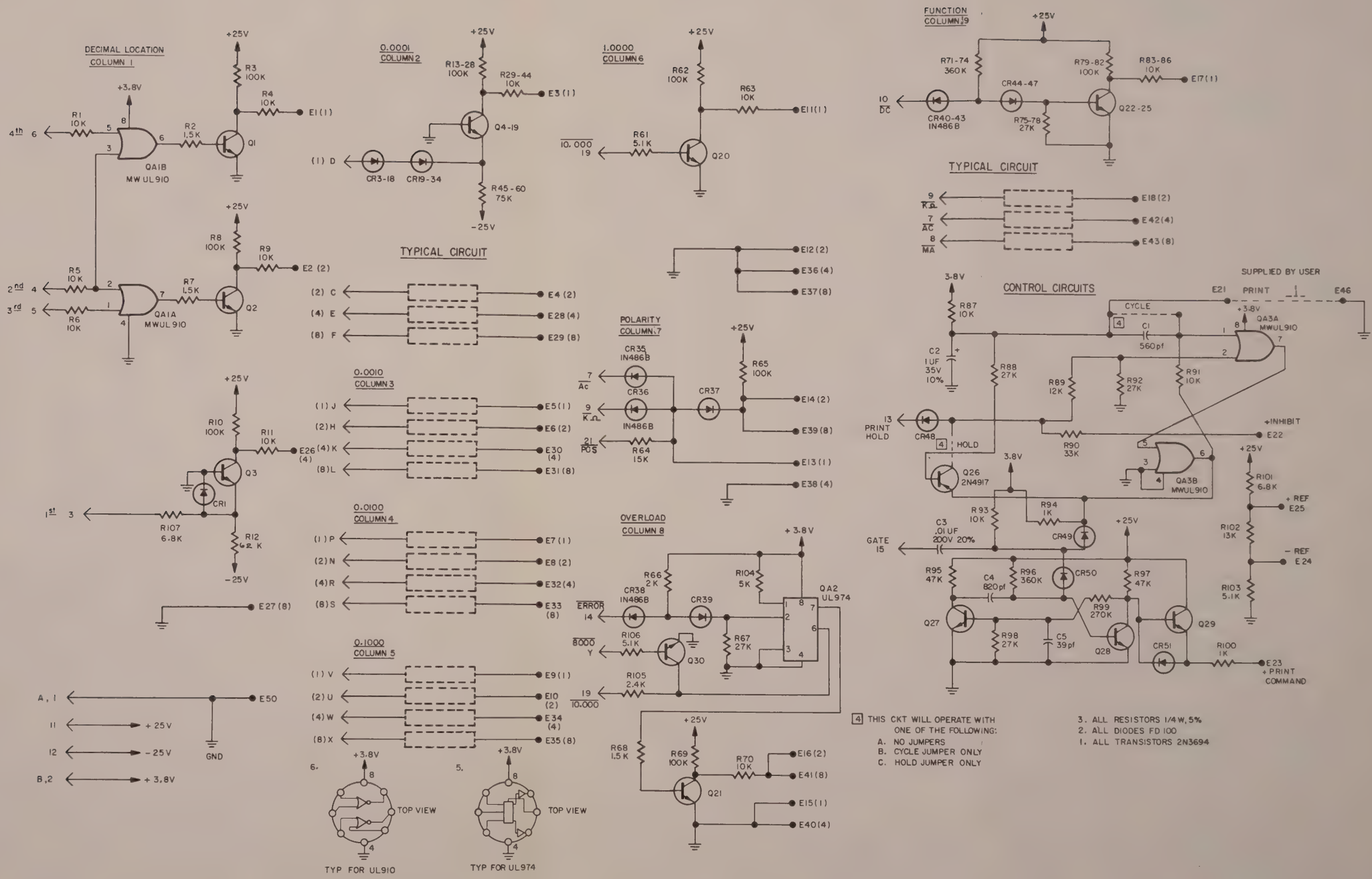


Figure 5-11. Schematic, BCD Assembly A3

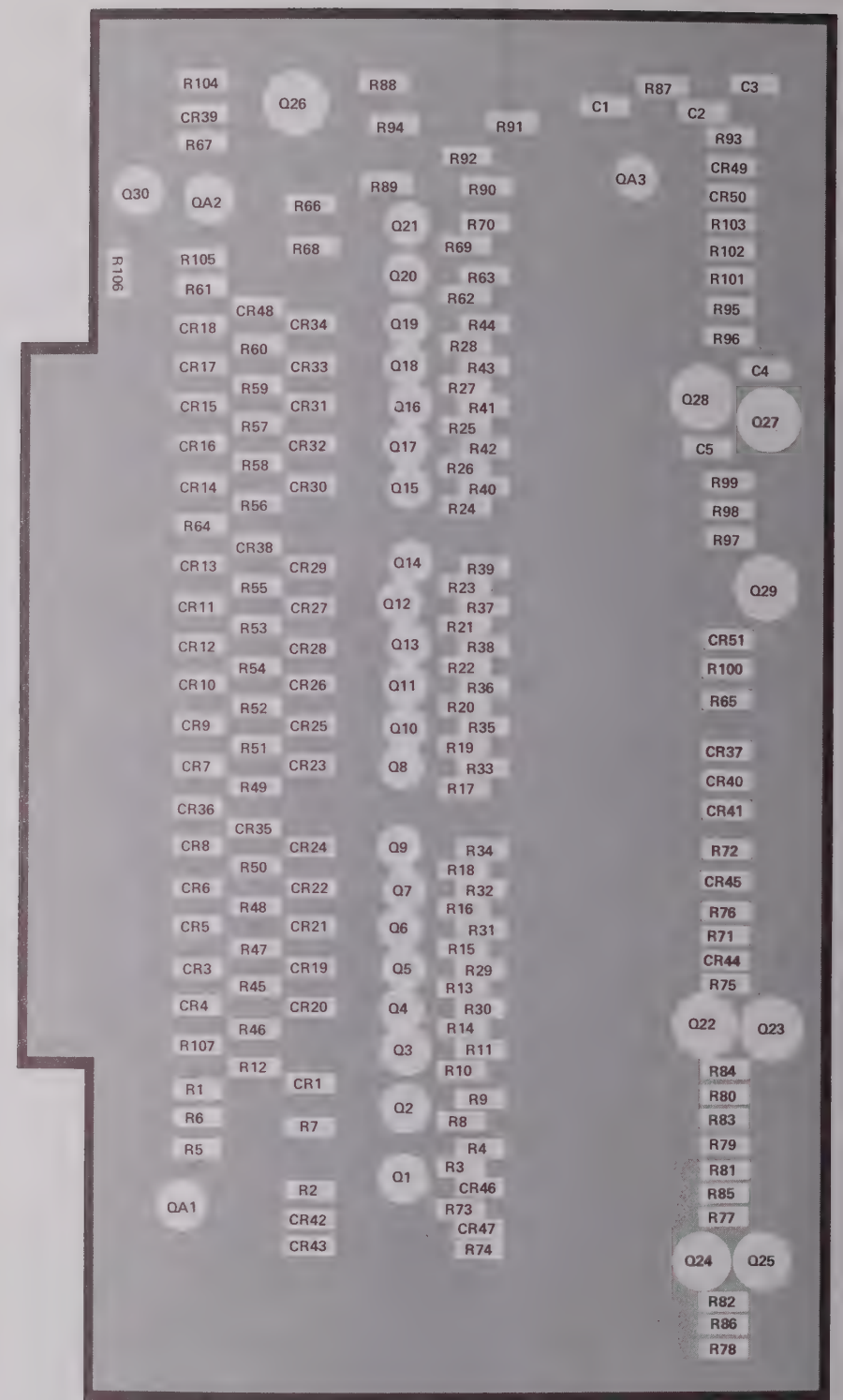


Figure 5-10. Component Location, BCD Assembly A3

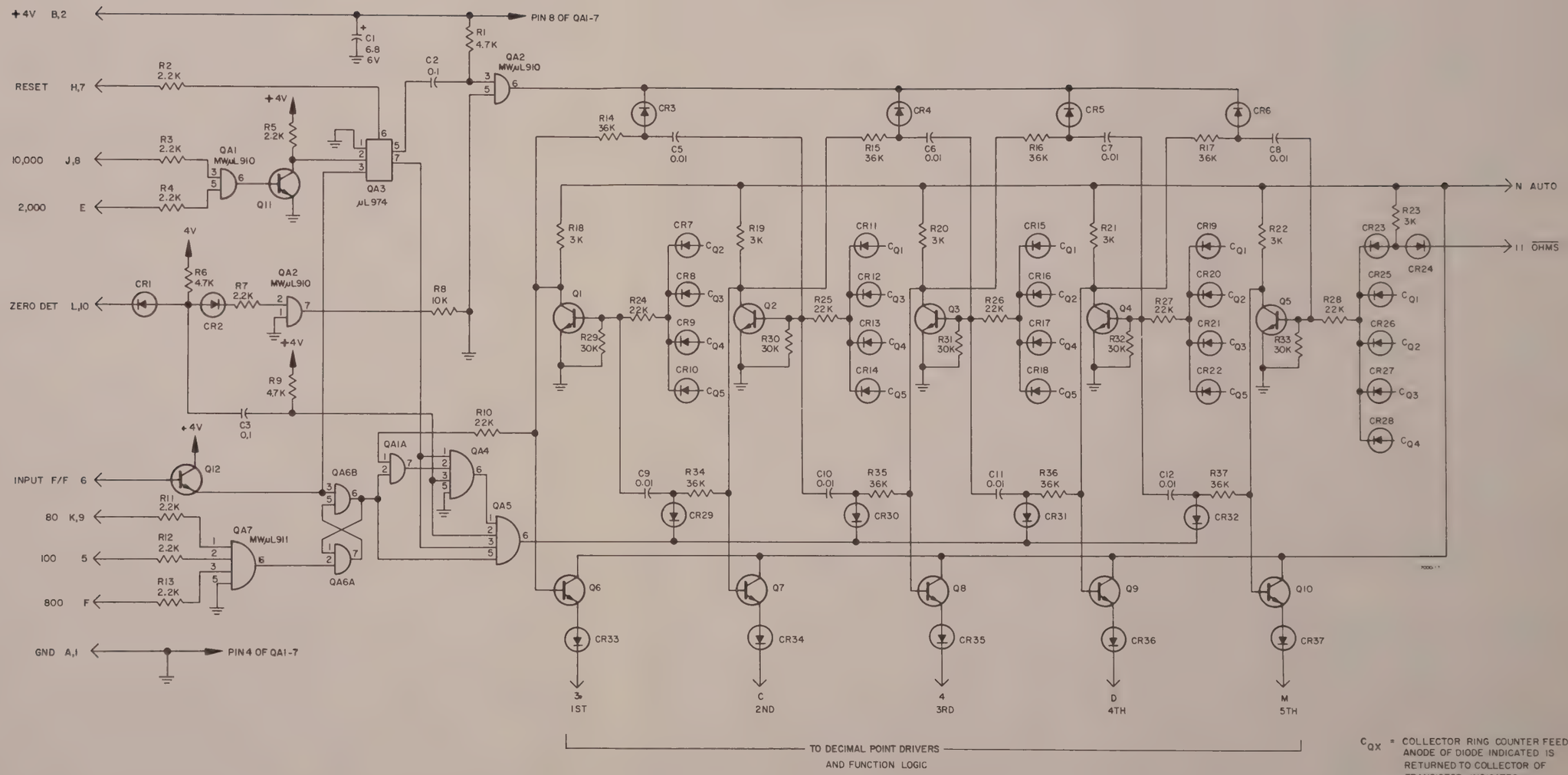


Figure 5-13. Schematic, Auto-Range Assembly A4

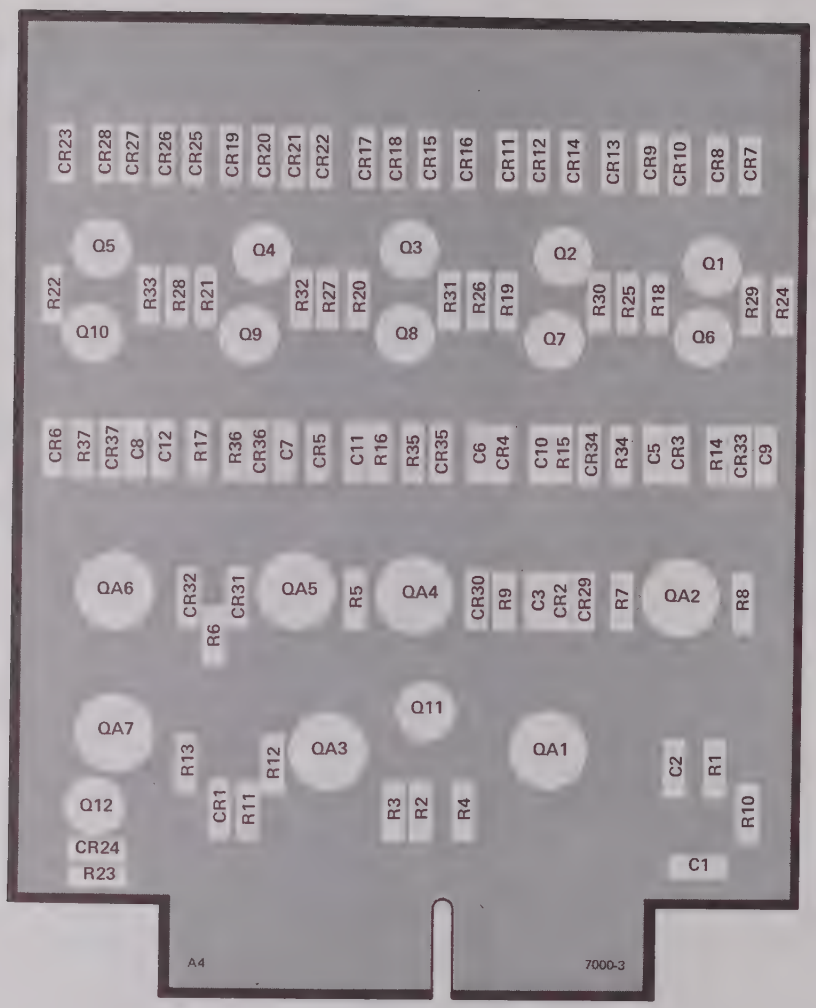


Figure 5-12. Component Location, Auto Range Assembly A4

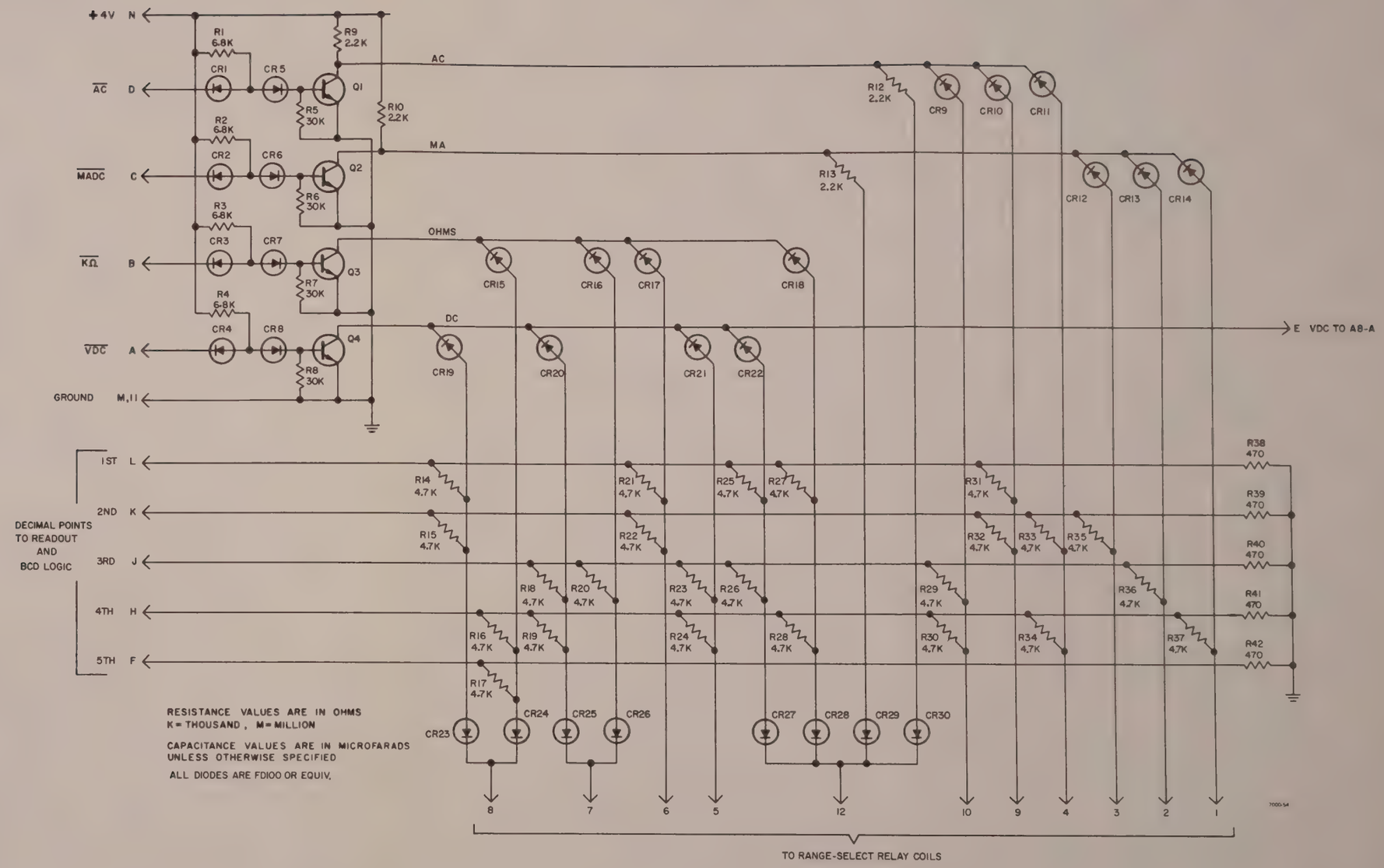


Figure 5-15. Schematic, Function Logic Assembly A5

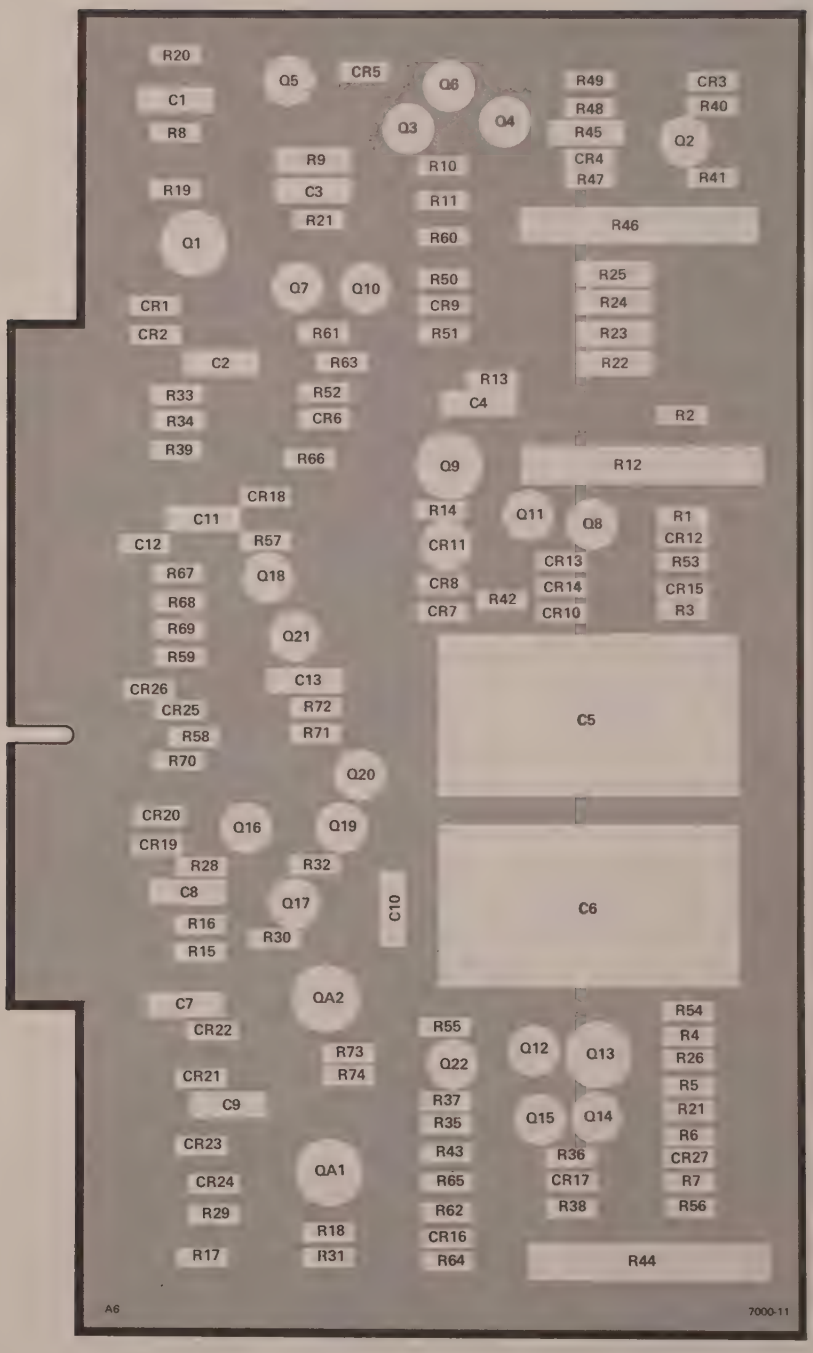


Figure 5-16. Component Location, A to D Converter Assembly A6

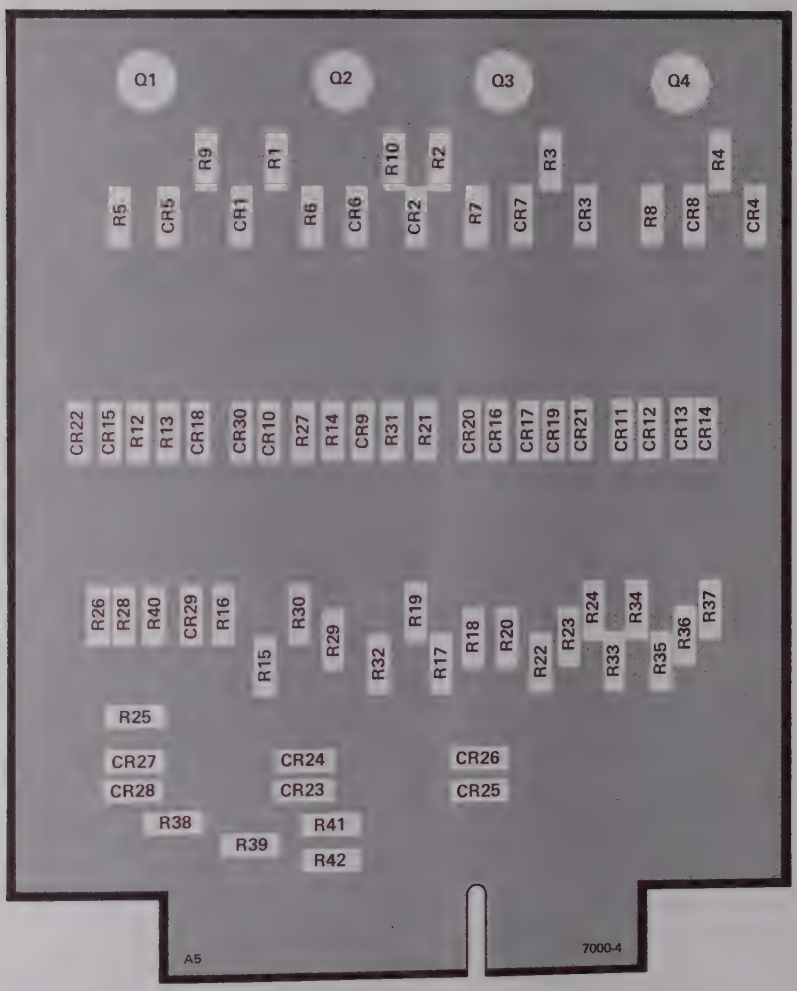


Figure 5-14. Component Location, Function Logic Assembly A5

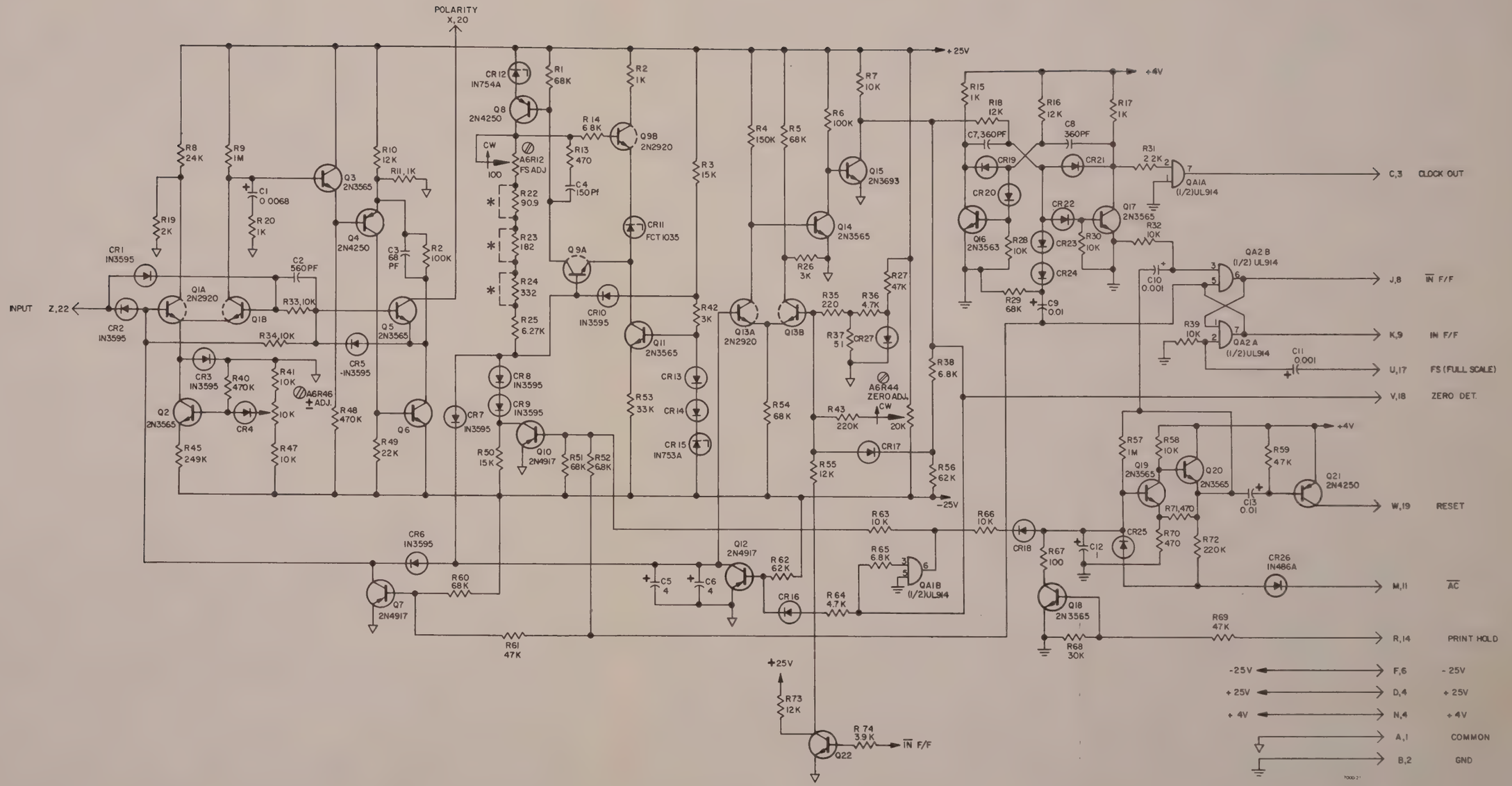


Figure 5-17. Schematic, A to D Converter Assembly A6

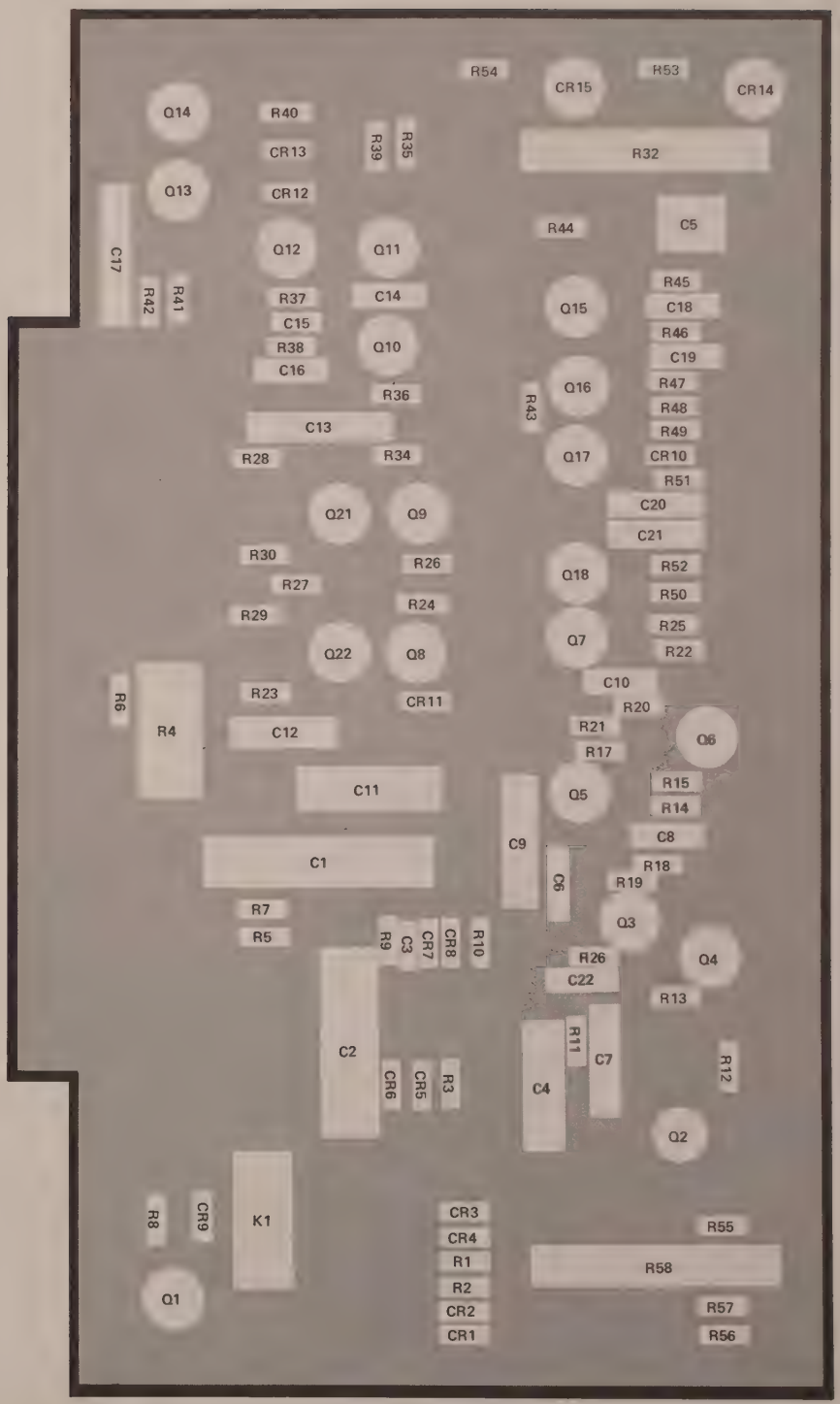


Figure 5-18. Component Location, Input Amplifier Assembly A7

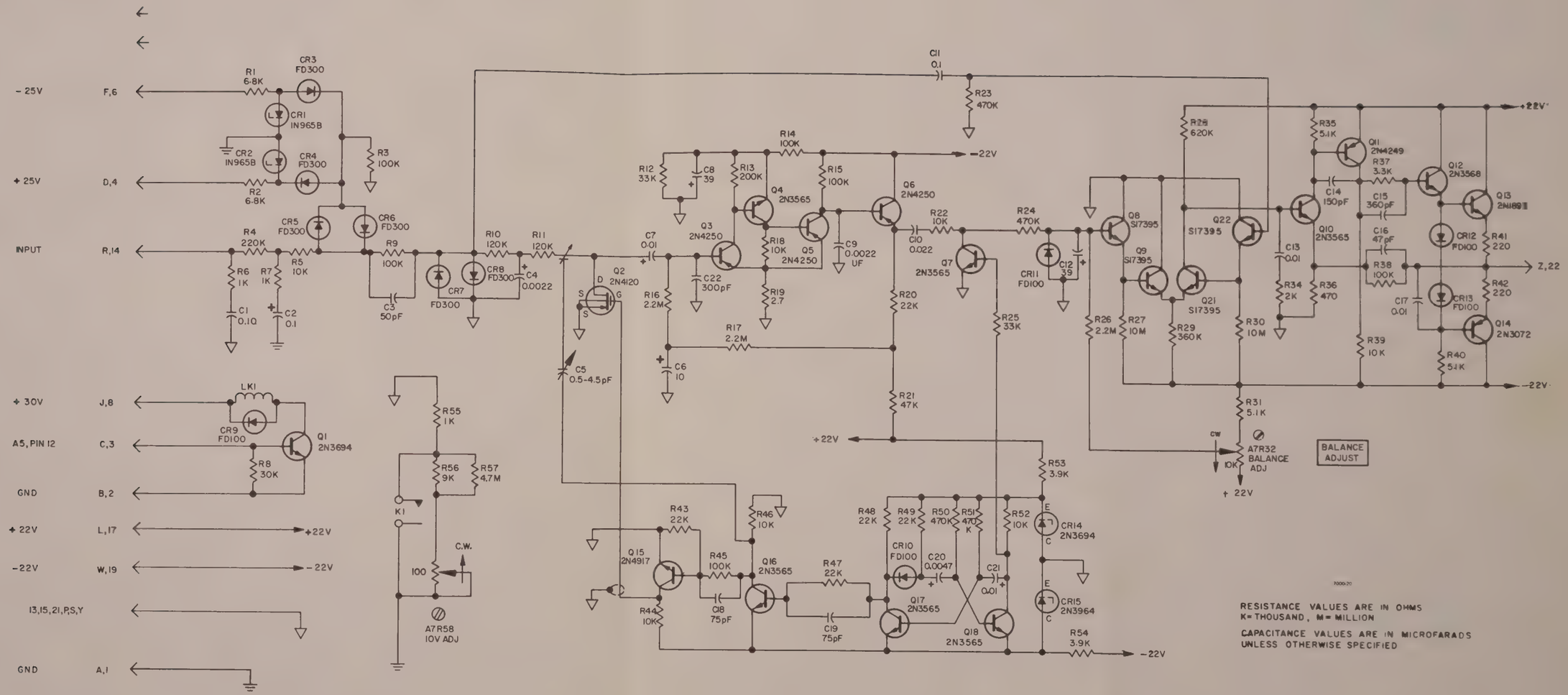


Figure 5-19. Schematic, Input Amplifier Assembly A7

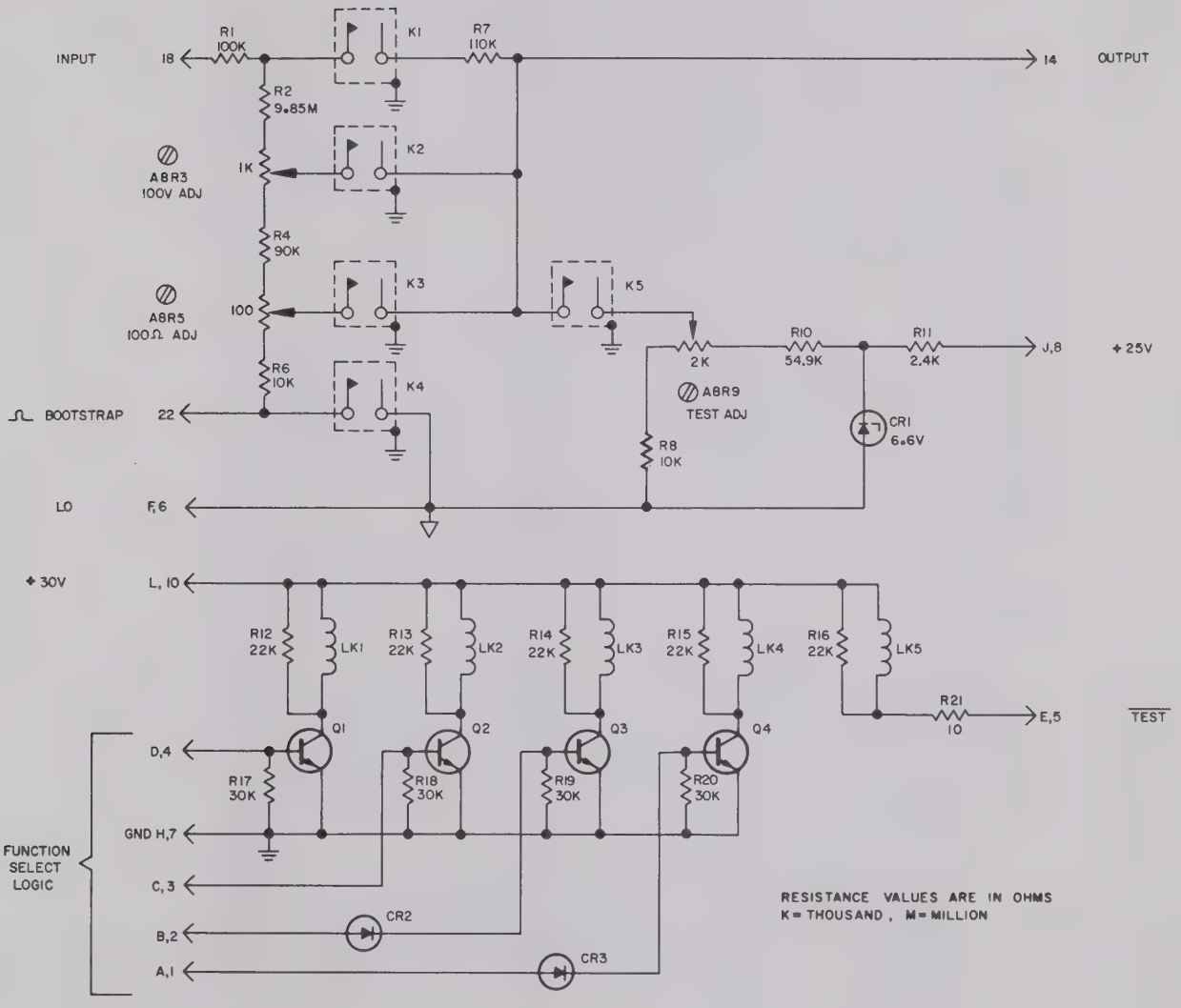


Figure 5-21. Schematic, DC Attenuator Assembly A8

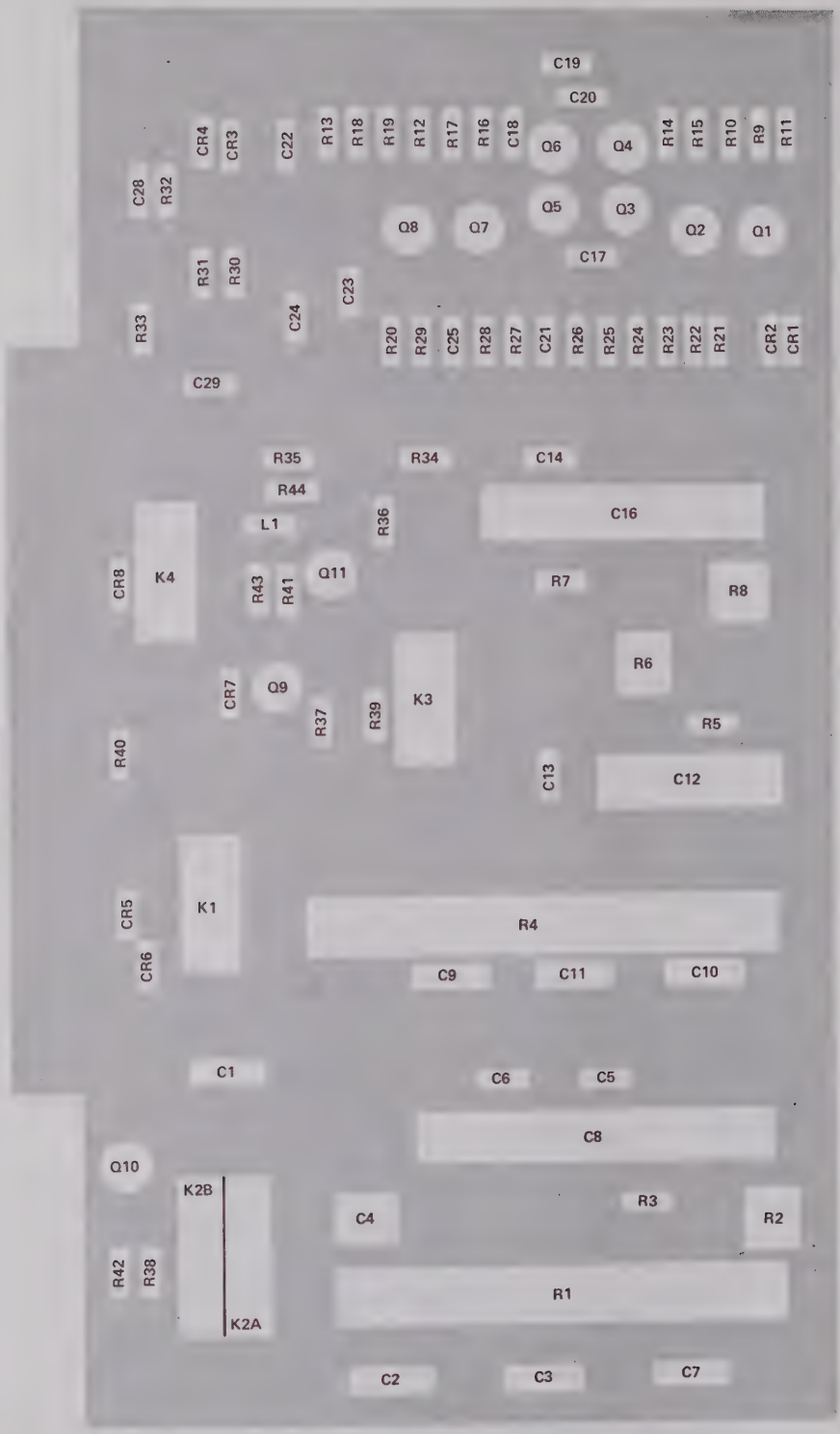


Figure 5-22. Component Location, AC to DC Converter Assembly A9

Figure 5-20. Component Location, DC Attenuator Assembly A8

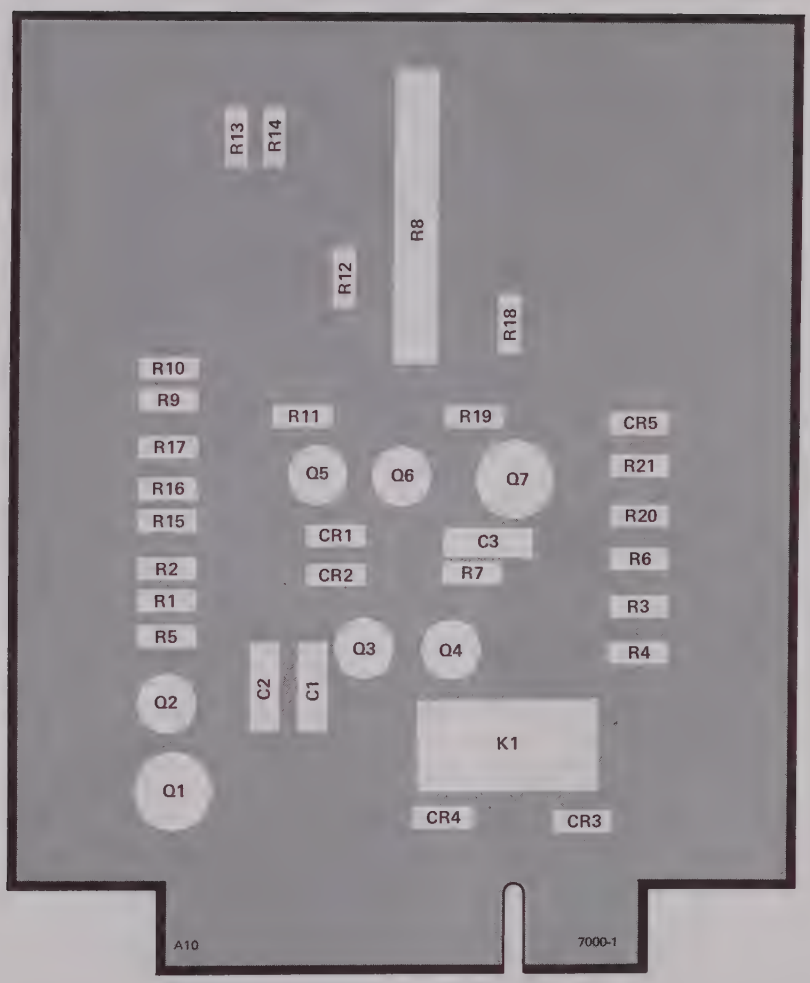


Figure 5-24. Component Location, Ohms Converter Assembly A10

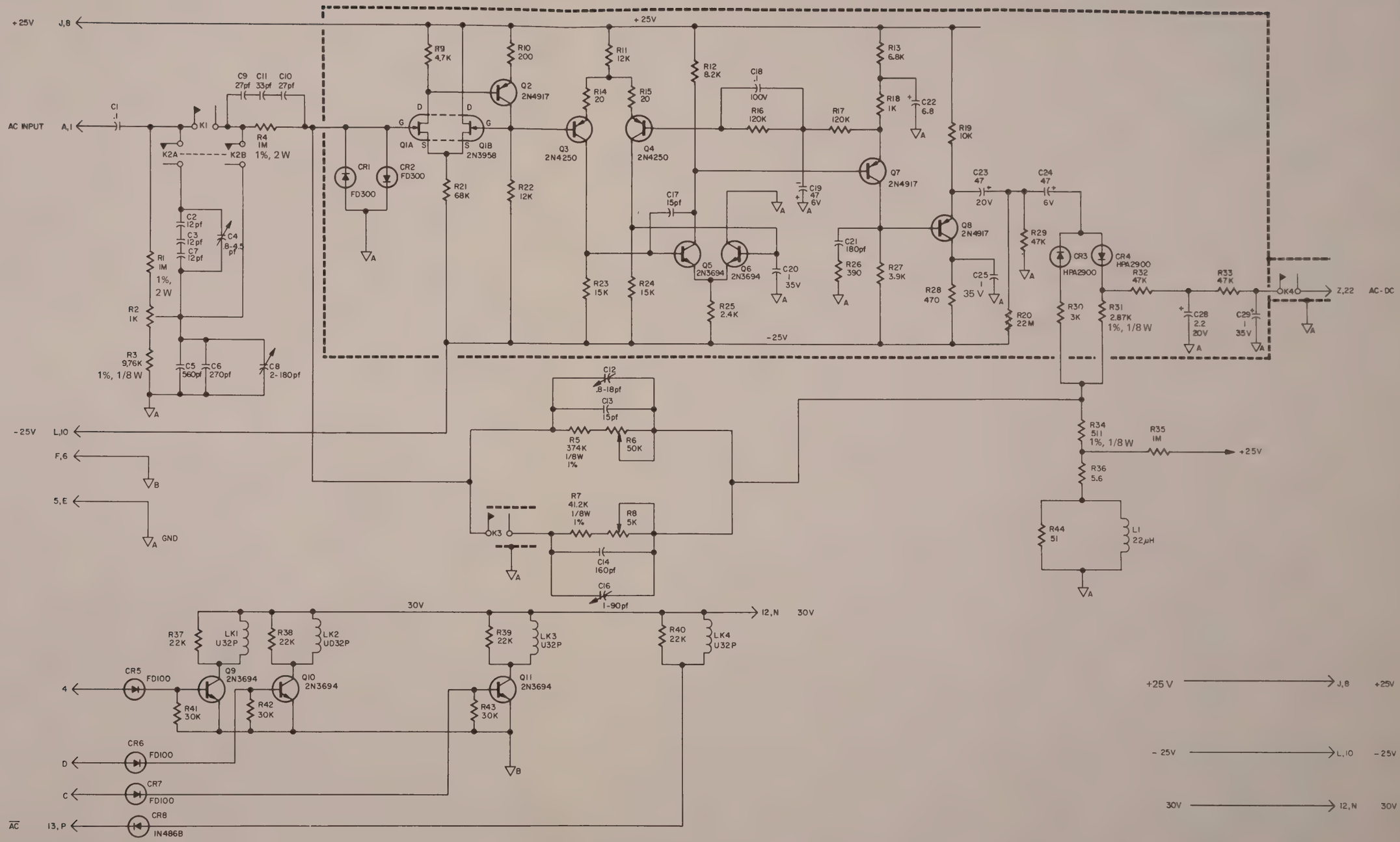
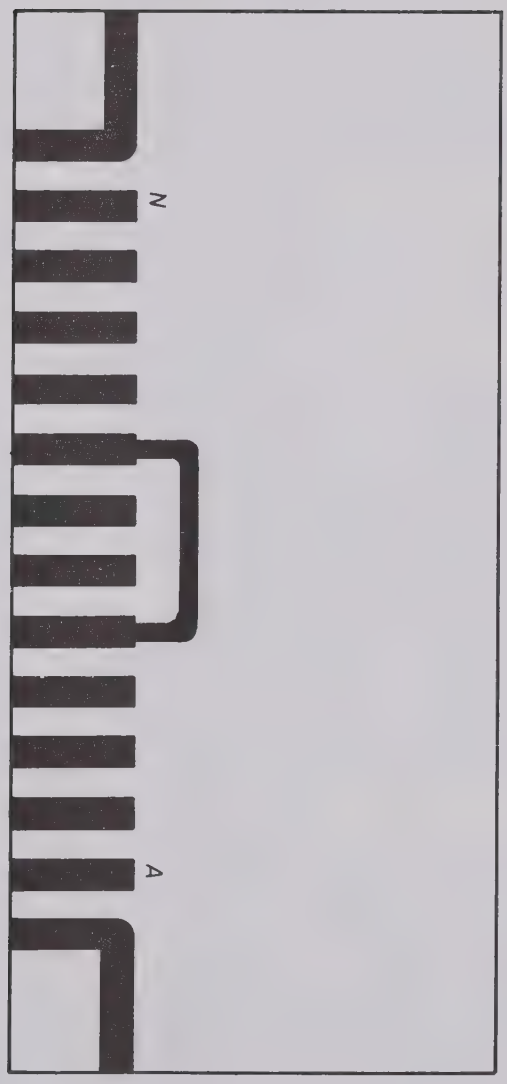


Figure 5-23. Schematic, AC to DC Converter Assembly A9



NOTE

A11 IS A JUMPER BOARD, AND IS USED WHEN AUTORANGE BOARD (OPTION 01) IS NOT INCLUDED.

Figure 5-26. Jumper Board Assembly A11

Figure 5-27. Component Location, Power Supply Assembly A12

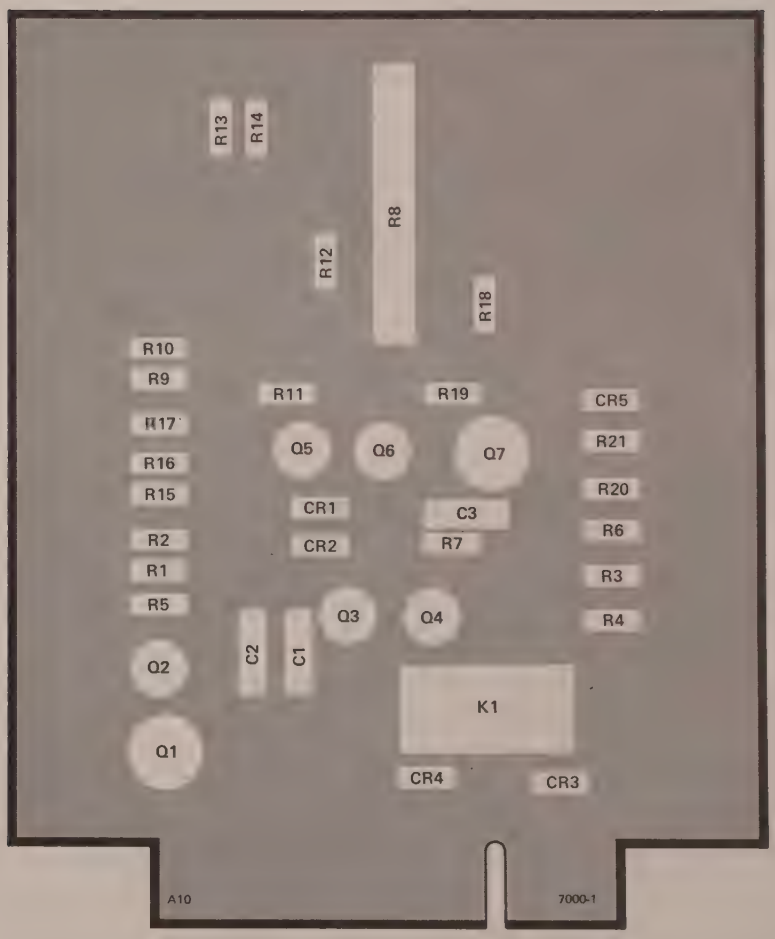
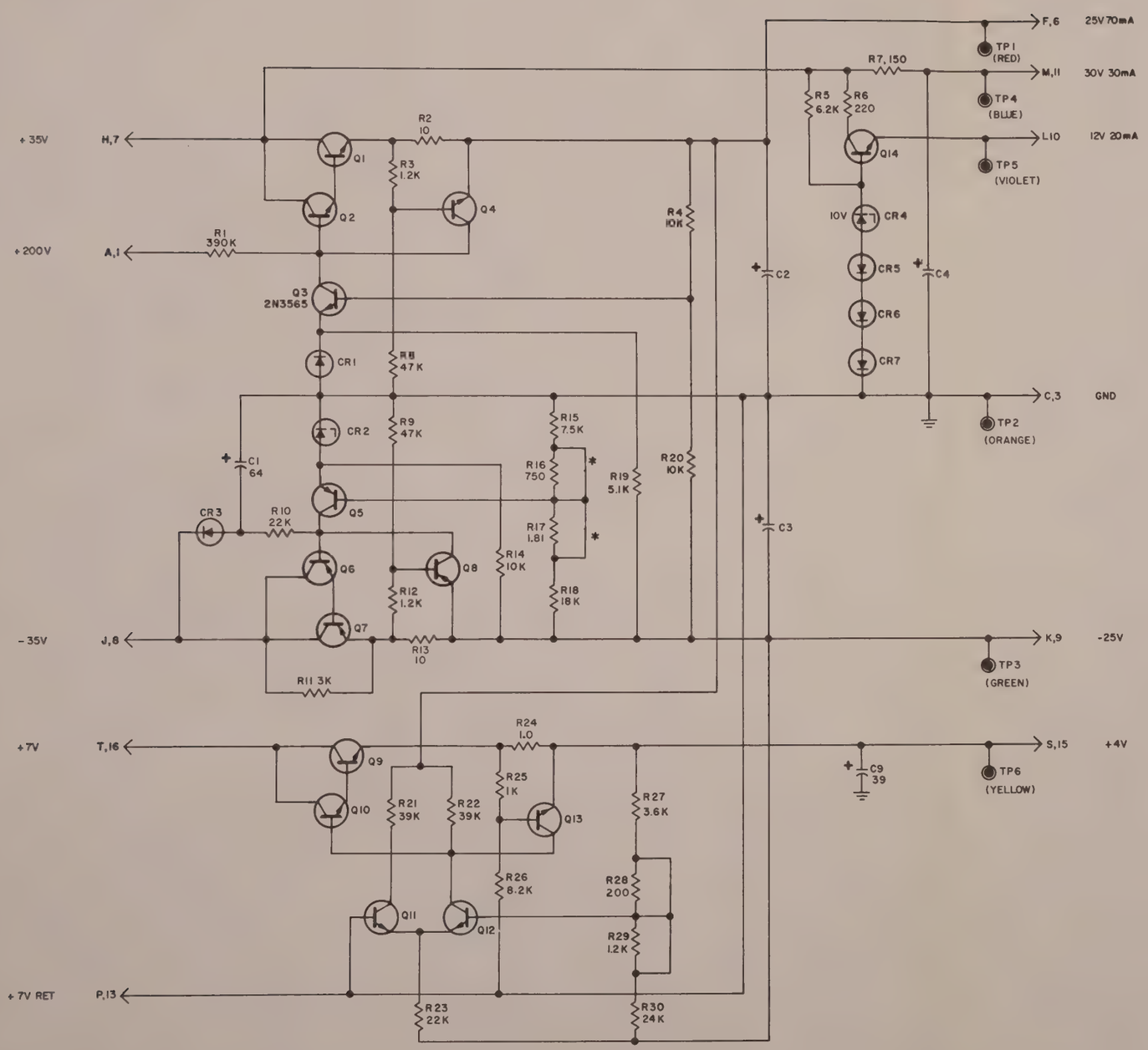
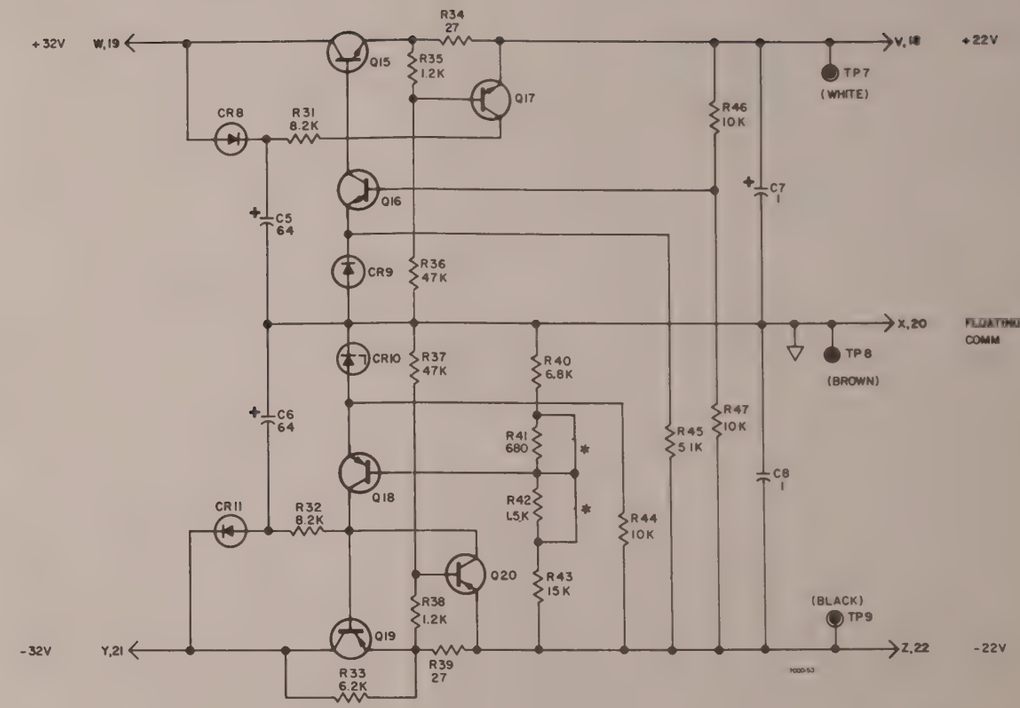


Figure 5-24. Component Location, Ohms Converter Assembly A10





RESISTANCE VALUES ARE IN OHMS
K= THOUSAND, M= MILLION

CAPACITANCE VALUES ARE IN MICROFARADS
UNLESS OTHERWISE SPECIFIED.

* CUT JUMPERS TO ADJUST.

Figure 5-28. Schematic, Power Supply Assembly A12

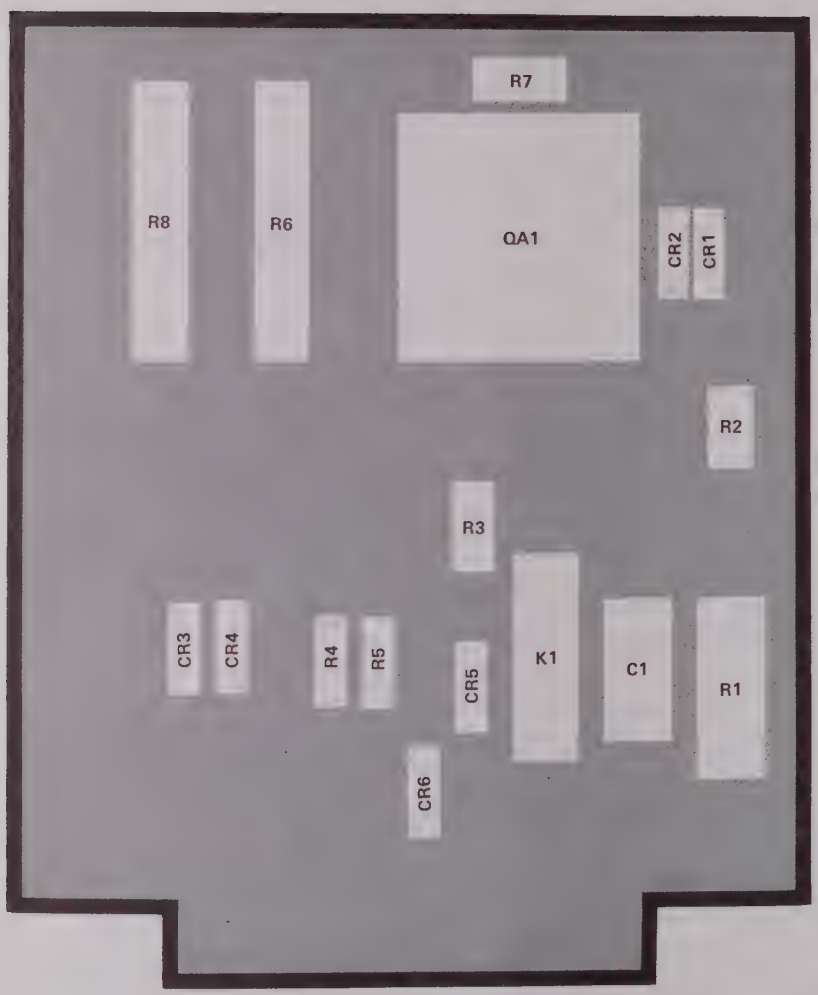


Figure 5-31. Component Location, mV Amplifier Assembly A15

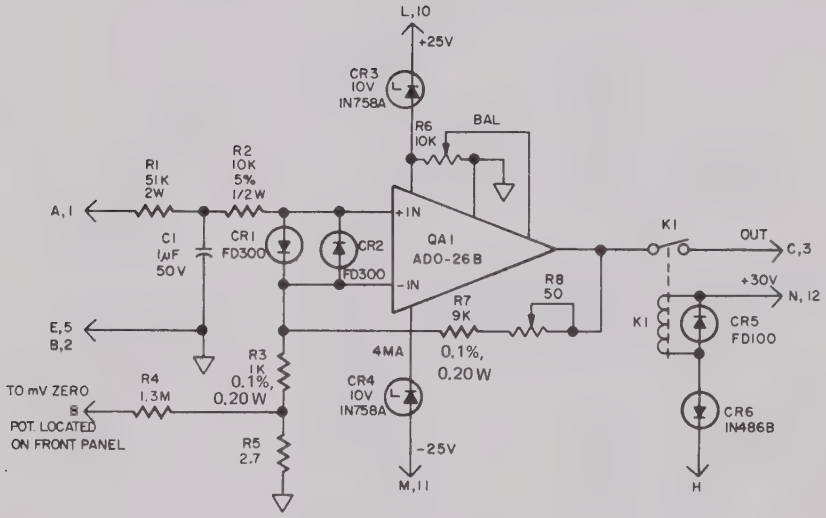


Figure 5-32. Schematic, mV Amplifier Assembly A15

Section VI
Replacement Parts

GENERAL

Tables 6-1 through 6-16 contain information for ordering replacement parts and list: circuit reference, description, manufacturer, and Fairchild Instrumentation part number. Physical location of electrical components and mechanical items are called out in section V and are cross-referenced with the parts list through the circuit reference numbers.

ORDERING INFORMATION

To order a replacement part, address the order to an authorized Fairchild Instrumentation sales representative, or to: 974 East Arques Avenue, Sunnyvale, California 94086.

Specify the following for each part:

a. Model and serial number of instrument.

b. Fairchild Instrumentation part number.

c. Circuit reference designation, assembly number, or complete description.

To order a part not listed in tables 6-1 through 6-16, provide a complete description of the part, including function and location.

ABBREVIATIONS

AB	Allen-Bradley Company
Alco	Alco Electronic Prods., Inc.
Amperex	Amperex Electric Corp.
Amphenol	Amphenol-Borg Electronics
Beckman	Beckman Instruments, Inc.
Carter	Carter Manufacturing Corp.
Cinch	Cinch Manufacturing Company
Corning	Corning Glass Works
Coto-Coil	Coto-Coil Company, Inc.
CTS	Chicago Telephone Supply
Dale	Dale Electronics Corp.
Dialco	Dialight Corporation
Elmenco	The Electro Motive Mfg. Co.
Elpac	Elpac Capacitors
Fansteel	Fansteel Metallurgical Corp.
FI	Fairchild Instrumentation
FS	Fairchild Semiconductor
Gordos	Gordos Corporation
Grayhill	Grayhill, Inc.
Hamlin	Hamlin, Inc.
H.H.Smith	H.H. Smith, Inc.
Hopkins	Hopkins Engineering Co.
IBM	International Bus. Machines
IRC	International Resistance Co.
JFD	JFD Electronic Corporation
Littlefuse	Littlefuse Corporation
Milton	Milton-Ross
Motorola	Motorola Semiconductor Prods.
Muter	The Muter Company
NE	National Electronics
Raytheon	Raytheon Components Div.
RCL	RCL Electronics, Inc.
Sangamo	Sangamo Electric Company
Sprague	Sprague Electric Company
Tower	Tower Manufacturing Corp.
TRW	TRW Capacitor Division
Viking	Viking Ind.
Vishay	Vishay Instrument, Inc.
West Cap	San Fernando Electric

Table 6-1. Model 7000A Parts List

Circuit Ref.	Description	Manufacturer	Number
A1	Assembly, Readout Board	FI	93000101
A2	Assembly, Counter	FI	93000102
A3	Assembly, BCD (Option)	FI	93000183
A4	Assembly, Auto Range (Option)	FI	93000184
A5	Assembly, Function Logic	FI	93000105
A6	Assembly, A-D Converter	FI	93000106
A7	Assembly, Input Amplifier	FI	93000107
A8	Assembly, DC Attenuator	FI	93000108
A9	Assembly, AC Converter (Option)	FI	93000189
A10	Assembly, Ohms Converter (Option)	FI	93000190
A11	Assembly, Jumper Board	FI	40036741
A12	Assembly, Power Regulator Board	FI	93000112
A13	Assembly, Mother Board	FI	93001413
A14	Assembly, Current Shunts (Option)	FI	93000194
A15	Assembly, Preamplifier (Option)	FI	93001485
DS1	Lamp, cartridge, red	Dialco	12013740
F1	Fuse, ½ A Slo-Blo, 125 V	Littlefuse	11009140
J1	Connector, AC	Tower	09061480
R1	Resistor, variable, 100 kΩ		01111730
S1	Switch, slide, 115 V/230 V	Muter	05033390
S2	Switch, toggle, SPDT	Alco	05032490
S3	Switch, Rotary 1 pol., 6 pos.	CTS	05029741
S4	Switch,	CTS	05029751
T1	Transformer (prewired)		93000142
TP1	Binding post, red	Grayhill	51017810
TP2	Binding post, black	Grayhill	51027800
TP3	Binding post, white	Grayhill	51023860
V1	Tube, readout, polarity	NE	25015520
V2	Tube, readout	NE	25015510
V3	Same as V2		
V4	Same as V2		
V5	Same as V2		
V6	Same as V2		
XF1	Fuseholder		11009210
	Miscellaneous–Main Assembly		
	Adapter, rear	FI	35079001
	Bail, tilt		35071973
	Bezel, front	FI	64018561
	Bracket, Mother Board LH		64020042
	Bracket, Mother Board RH		64020032
	Cord, power		41013140

Table 6-1. Model 7000A Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
	Cover, top	FI	33042461
	Cover, bottom	FI	33042501
	Foot, instrument	FI	38020031
	Guide, card		64018490
	Guide, card		64018370
	Handle, strap	FI	64018611
	Knob (2)	Raytheon	45011420
	Nut, speed T type		36011680
	Nut, Keps 6-32 x ¼		61039370
	Nut, self lock 6-32		61039340
	Rails, side		35078051
	Screw, black 6-32 x ¼		60516010
	Screw, FH SS black 8-32 x 7/8		60112730
	Screw, Ph CR 6-32 x 3/8		60112650
	Screw, PH CR 6-32 x 5/16		60516520
	Screw, Ph CR black 6-32 x 5/16		60516000
	Screw, FH CR 6-32 x 1/8		60112540
	Screw, Ph CR 4-40 x ¾		60516460
	Screw, FH CR 4-40 x 3/8		60112540
	Miscellaneous—Front Panel		
	Fastener, clip-on		36011690
	Filter, readout		48006661
	Nut, Keps 6-32 x ¼		61039370
	Screw, FH CR 6-32 x 5/16		60512620
	Miscellaneous—Rear Panel		
	Cover, connector		35077811
	Nut, self-lock 8-32		61039480
	Screw, Ph CR 8/32 x 3/8		60913600
	Screw, Ph CR 4-40 x 3/8		60516410
	Washer, flat No. 8		62003680
	Miscellaneous—Readout Assembly		
	Bracket, readout tubes		35071752
	Grommet, 3/16" I.D. 5/16" Hole	HH Smith	38023770
	Screw, Ph CR 4-40 x ¼		60516390
	Washer, lock No. 4		62106350

Table 6-2. Readout Assembly A1 Parts List

Circuit Ref.	Description	Manufacturer	Number
A1	A1 PC Board		40036631
R1 through R6	Resistor, fixed, 20 kΩ ±5%, ½ W	AB	02030790
XV1 through XV6	Socket, tube, RTS-18	NE	34011530

Table 6-3. Counter Assembly A2 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, .01 μF, 200 V	Sprague	03278670
C2	Capacitor, fixed, 6.8 μF, 6 V	Sprague	03280370
C3	Capacitor, fixed, 680 pF, 300 V	Elmenco	03281540
C4	Capacitor, fixed, .1 μF, 200 V	TRW	03278960
CR1	Diode, FD100	FS	26006930
CR2 through CR5	Same as CR1		
CR6	Diode, 1N486A	FS	26014570
CR7	Same as CR6		
Q1	Transistor, S20364 NPN	FS	26004021
Q2	Same as Q1		
Q3	Transistor, 2N3693	FS	26012020
Q4	Transistor, 2N720A	FS	26010850
Q5	Transistor, 2N3563	FS	26012050
Q6	Same as Q3		
Q7 through Q12	Same as Q4		
QA1	Micrologic element, μL914	FS	26010980
QA2	Micrologic element, μL974	FS	26012480
QA3	Same as QA1		
QA4	Micrologic element, CμL960	FS	26012430
QA5	Same as QA4		
QA6	Same as QA4		
QA7	Same as QA4		
QA8	Micrologic element, CμL959	FS	26012420
QA9	Same as QA8		
QA10	Same as QA8		
QA11	Same as QA8		
QA12	Micrologic element, CμL958	FS	26012410
QA13	Same as QA12		
QA14	Same as QA12		
QA15	Same as QA12		
QA16	Same as QA1		
QA17	Same as QA2		
QA18	Same as QA2		
R1 through R6	Not assigned		
R7	Resistor, fixed, 2.7 MΩ ±5%, ¼ W	AB	02355430
R8	Resistor, fixed, 270 kΩ ±5%, ¼ W	AB	02355190
R9	Same as R8		
R10	Resistor, fixed, 1 MΩ ±5%, ¼ W	AB	02355330
R11	Resistor, fixed, 1.5 MΩ ±5%, ¼ W	AB	02355370

Table 6-3. Counter Assembly A2 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
R12	Resistor, fixed, 2 kΩ ±5%, ¼ W	AB	02354680
R13	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R14	Resistor, fixed, 30 kΩ ±5%, ¼ W	AB	02354960
R15	Same as R8		
R16	Same as R14		
R17	Resistor, fixed, 2.2 kΩ ±5%, ¼ W	AB	02354690
R18	Same as R17		
R19	Same as R17		
R20	Same as R17		
R21	Resistor, fixed, 100 Ω ±5%, ¼ W	AB	02354380
R22	Same as R14		
R23	Same as R14		
R24	Resistor, fixed, 6.8 kΩ ±5%, ¼ W	AB	02354810
R25	Same as R17		
R26	Same as R17		
R27	Same as R21		
R28	Same as R14		
R29	Same as R14		
R30	Same as R21		
R31	Same as R14		
R32	Same as R14		
R33	Same as R21		
R34	Same as R14		
R35	Same as R14		
R36	Resistor, fixed, 4.7 kΩ ±5%, ¼ W	AB	02354770
R37	Same as R14		
R38	Same as R14		
R39	Same as R36		
R40	Resistor, fixed, 75 kΩ ±5%, ¼ W	AB	02355060
R41	Same as R40		
R42	Same as R40		
R43	Same as R40		
R44 through R47	Same as R8		
R48	Resistor, fixed, 10 Ω ±5%, ¼ W	AB	02354140
XA1	Connector, 56 pin	Viking	09060800

Table 6-4. BCD Converter Assembly A3 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 560 pF, 300 V	Elmenco	03281520
C2	Capacitor, fixed, 1 μF, 35 V	Sprague	03279130
C3	Capacitor, fixed, .01 μF, 200 V	Elpac	03286710
C4	Capacitor, fixed, 820 pF, 300 V	Elmenco	03281560
C5	Capacitor, fixed, 39 pF, 500 V	Elmenco	03175170
CR1	Diode, FD100	FS	26006930
CR2	Not assigned		
CR3 through CR34	Same as CR1		
CR35	Diode, 1N486B	FS	26015330
CR36	Same as CR35		
CR37	Same as CR1		
CR38	Same as CR35		
CR39	Same as CR1		
CR40 through CR43	Same as CR35		
CR44 through CR51	Same as CR1		
J1	Connector, 50 pin	Amphenol	09062870
Q1 through Q25	Transistor, 2N3694	FS	26012660
Q26	Transistor, 2N4917	FS	26014620
Q27	Same as Q1		
Q28	Same as Q1		
Q29	Same as Q1		
Q30	Same as Q1		
QA1	Micrologic element, MWμL910	FS	26011160
QA2	Micrologic element, μL974	FS	26012480
QA3	Same as QA1		
R1	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R2	Resistor, fixed, 1.5 kΩ ±5%, ¼ W	AB	02354650
R3	Resistor, fixed, 100 kΩ ±5%, ¼ W	AB	02355090
R4	Same as R1		
R5	Same as R1		
R6	Same as R1		
R7	Same as R2		

Table 6-4. BCD Converter Assembly A3 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
R8	Same as R3		
R9	Same as R1		
R10	Same as R3		
R11	Same as R1		
R12	Resistor, fixed, 75 kΩ ±5%, ¼ W	AB	02355060
R13 through R28	Same as R3		
R29	Same as R1		
R30	Same as R1		
R31 through R44	Same as R1		
R45	Same as R12		
R46	Same as R12		
R47 through R60	Same as R12		
R61	Resistor, fixed, 5.1 kΩ ±5%, ¼ W	AB	02354780
R62	Same as R3		
R63	Same as R1		
R64	Resistor, fixed, 15 kΩ ±5%, ¼ W	AB	02354890
R65	Same as R3		
R66	Resistor, fixed, 2 kΩ ±5%, ¼ W	AB	02354680
R67	Resistor, fixed, 27 kΩ ±5%, ¼ W	AB	02354950
R68	Same as R2		
R69	Same as R3		
R70	Same as R1		
R71	Resistor, fixed, 360 kΩ ±5%, ¼ W	AB	02355220
R72	Same as R71		
R73	Same as R71		
R74	Same as R71		
R75 through R78	Same as R67		
R79 through R82	Same as R3		
R83	Same as R1		
R84	Same as R1		
R85	Same as R1		
R86	Same as R1		
R87	Same as R1		

Table 6-4. BCD Converter Assembly A3 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
R88	Same as R67		
R89	Resistor, fixed, 12 kΩ ±5%, ¼ W	AB	02354870
R90	Resistor, fixed, 33 kΩ ±5%, ¼ W	AB	02354970
R91	Same as R1		
R92	Same as R67		
R93	Same as R1		
R94	Resistor, fixed, 1 kΩ ±5%, ¼ W	AB	02354620
R95	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R96	Same as R71		
R97	Same as R95		
R98	Same as R67		
R99	Resistor, fixed, 270 kΩ ±5%, ¼ W	AB	02355190
R100	Same as R94		
R101	Resistor, fixed, 6.8 kΩ ±5%, ¼ W	AB	02354810
R102	Resistor, fixed, 13 kΩ ±5%, ¼ W	AB	02354880
R103	Same as R61		
R104	Same as R61		
R105	Resistor, fixed, 2.4 kΩ ±5%, ¼ W	AB	02354700
R106	Same as R61		
R107	Same as R101		

Table 6-5. Auto Range Assembly A4 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 6.8 μF, 6 V	Sprague	03280370
C2	Capacitor, fixed, 0.1 μF, 100 V	West Cap	03289110
C3	Same as C2		
C4	Capacitor, fixed, 0.0022 μF, 100 V	West Cap	03284750
C5	Capacitor, fixed, 0.01 μF, 200 V	West Cap	03286710
C6 through C12	Same as C5		
CR1 through CR23	Diode, FD100	FS	26006930
CR24	Diode, 1N486A	FS	26014570
CR25	Same as CR1		
CR26 through CR37	Same as CR1		
Q1 through Q12	Transistor, 2N3563	FS	26012050
QA1	Micrologic element, MWμL910	FS	26011160
QA2	Same as QA1		
QA3	Micrologic element, μL974	FS	26012480
QA4	Micrologic element, MWμL911	FS	26011920
QA5	Same as QA4		
QA6	Same as QA1		
QA7	Same as QA4		
R1	Resistor, fixed, 4.7 kΩ ±5%, ¼ W	AB	02354770
R2	Resistor, fixed, 2.2 kΩ ±5%, ¼ W	AB	02354690
R3	Same as R2		
R4	Same as R2		
R5	Same as R2		
R6	Same as R1		
R7	Same as R2		
R8	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R9	Same as R1		
R10	Resistor, fixed, 22 kΩ ±5%, ¼ W	AB	02354930
R11	Same as R2		
R12	Same as R2		
R13	Same as R2		
R14	Resistor, fixed, 36 kΩ ±5%, ¼ W	AB	02354980
R15	Same as R14		
R16	Same as R14		
R17	Same as R14		
R18	Resistor, fixed, 3 kΩ ±5%, ¼ W	AB	02354720
R19	Same as R18		

Table 6-5. Auto Range Assembly A4 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
R20 through R23	Same as R18		
R24	Same as R10		
R25	Same as R10		
R26	Same as R10		
R27	Same as R10		
R28	Same as R10		
R29	Resistor, fixed, 30 kΩ ±5%, ¼ W	AB	02354960
R30	Same as R29		
R31	Same as R29		
R32	Same as R29		
R33	Same as R29		
R34	Same as R14		
R35	Same as R14		
R36	Same as R14		
R37	Same as R14		

Table 6-6. Function Logic Assembly A5 Parts List

Circuit Ref.	Description	Manufacturer	Number
CR1	Diode, 1N486A	FS	26014570
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Diode, FD100	FS	26006930
CR6 through CR30	Same as CR5		
Q1 through Q4	Transistor, fixed, 2N3563	FS	26012050
R1 through R4	Resistor, fixed, 6.8 kΩ ±5%, ¼ W	AB	02354810
R5	Resistor, fixed, 30 kΩ ±5%, ¼ W	AB	02354960
R6	Same as R5		
R7	Same as R5		
R8	Same as R5		
R9	Resistor, fixed, 2.2 kΩ ±5%, ¼ W	AB	02354690
R10	Same as R9		
R11	Not Assigned		
R12	Same as R9		
R13	Same as R9		
R14	Resistor, fixed, 4.7 kΩ ±5%, ¼ W	AB	02354770
R15	Same as R14		
R16	Same as R14		
R17 through R37	Same as R14		
R38	Resistor, fixed, 470 Ω ±5%, ¼ W	AB	02354540
R39	Same as R38		
R40	Same as R38		
R41	Same as R38		
R42	Same as R38		

Table 6-7. A-D Converter Assembly A6 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 0.0068 μF, 200 V	TRW	03278890
C2	Capacitor, fixed, 560 pF, 300 V	Elmenco	03281520
C3	Capacitor, fixed, 68 pF, 300 V	Elmenco	03175240
C4	Capacitor, fixed, 150 pF, 300 V	Elmenco	03281360
C5	Capacitor, fixed, 4 μF, 100 V	TRW	03287640
C6	Same as C5		
C7	Capacitor, fixed, 360 pF, 500 V	Elmenco	03281460
C8	Same as C7		
C9	Capacitor, fixed, 0.01 μF, 200 V	TRW	03278910
C10	Capacitor, fixed, 0.001 μF, 100 V	TRW	03278790
C11	Same as C10		
C12	Capacitor, fixed, 1 μF, 35 V	Sprague	03279130
C13	Same as C9		
CR1	Diode, 1N3595	FS	26012540
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Diode, FD100	FS	26006930
CR5	Same as CR1		
CR6 through CR10	Same as CR10		
CR11	Transistor, FCT1035	FS	26014260
CR12	Diode, 1N754A	FS	26014220
CR13	Same as CR4		
CR14	Same as CR4		
CR15	Diode, 1N753A	FS	26014210
CR16	Same as CR4		
CR17	Same as CR4		
CR18 through CR25	Same as CR4		
CR26	Diode, 1N486A	FS	26014570
CR27	Same as CR4		
Q1	Transistor, 2N2920	FS	26011350
Q2	Transistor, 2N3565	FS	26012000
Q3	Same as Q2		
Q4	Transistor, 2N4250	FS	26014430
Q5	Transistor, 2N2484	FS	26010670
Q6	Same as Q2		
Q7	Transistor, 2N4121	FS	26012650
Q8	Same as Q4		
Q9	Same as Q1		
Q10	Same as Q7		
Q11	Same as Q2		
Q12	Same as Q7		
Q13	Same as Q1		

Table 6-7. A-D Converter Assembly A6 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
Q14	Same as Q2		
Q15	Transistor, 2N3693	FS	26012020
Q16	Transistor, 2N3563	FS	26012050
Q17	Same as Q16		
Q18	Same as Q2		
Q19	Same as Q2		
Q20	Same as Q2		
Q21	Same as Q4		
Q22	Same as Q15		
QA1	Micrologic element, μL914	FS	26012450
QA2	Same as QA1		
R1	Resistor, fixed, 68 kΩ ±2%, ¼ W	Corning	02397820
R2	Resistor, fixed, 1 kΩ ±5%, ¼ W	AB	02354620
R3	Resistor, fixed, 15 kΩ ±5%, ¼ W	AB	02354890
R4	Resistor, fixed, 150 kΩ ±2%, ¼ W	Corning	02397900
R5	Resistor, fixed, 68 kΩ ±5%, ¼ W	AB	02355050
R6	Resistor, fixed, 100 kΩ ±5%, ¼ W	AB	02355090
R7	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R8	Resistor, fixed, 24 kΩ ±5%, ¼ W	AB	02354940
R9	Resistor, fixed, 1 MΩ ±1%, 1/8 W	IRC	02394780
R10	Resistor, fixed, 12 kΩ ±5%, ¼ W	AB	02354870
R11	Same as R2		
R12	Resistor, variable, 100 Ω, ¾ W	Beckman	01110230
R13	Resistor, fixed, 470 Ω ±5%, ¼ W	AB	02354540
R14	Resistor, fixed, 6.8 kΩ ±5%, ¼ W	AB	02354810
R15	Same as R2		
R16	Same as R10		
R17	Same as R2		
R18	Same as R10		
R19	Resistor, fixed, 2 kΩ ±5%, ¼ W	AB	02354680
R20	Same as R2		
R21	Same as R6		
R22	Resistor, fixed, 90.9 Ω ±1%, 1/8 W	IRC	02398490
R23	Resistor, fixed, 182 Ω ±1%, 1/8 W	IRC	02398510
R24	Resistor, fixed, 332 Ω ±1%, 1/8 W	IRC	02398520
R25	Resistor, fixed, 6.27 kΩ ±.1%, ¼ W	Vishay	02391440
R26	Resistor, fixed, 3 kΩ ±5%, ¼ W	AB	02354720
R27	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R28	Same as R7		
R29	Same as R5		
R30	Same as R7		
R31	Resistor, fixed, 2.2 kΩ ±5%, ¼ W	AB	02354690
R32	Same as R7		
R33	Resistor, fixed, 10 kΩ ±.01%,.3 W	Vishay	02398710
R34	Same as R33		

Table 6-7. A-D Converter Assembly A6 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
R35	Resistor, fixed, 220 Ω ±5%, ¼ W	AB	02354460
R36	Resistor, fixed, 4.7 kΩ ±5%, ¼ W	AB	02354770
R37	Resistor, fixed, 51 Ω ±5%, ¼ W	AB	02354310
R38	Same as R14		
R39	Same as R7		
R40	Resistor fixed, 470 kΩ ±5%, ¼ W	AB	02355280
R41	Resistor, fixed, 10 kΩ ±2%, ¼ W	Corning	02397620
R42	Same as R26		
R43	Resistor, fixed, 220 kΩ ±5%, ¼ W	AB	02355170
R44	Resistor, variable, 20 kΩ, ¾ W	Beckman	01110300
R45	Resistor, fixed, 249 kΩ ±1%, 1/8 W	IRC	02394740
R46	Resistor, variable, 10 kΩ, ¾ W	Beckman	01110290
R47	Same as R41		
R48	Same as R40		
R49	Resistor, fixed, 22 kΩ ±5%, ¼ W	AB	02354930
R50	Same as R3		
R51	Same as R5		
R52	Same as R14		
R53	Resistor, fixed, 33 kΩ ±2%, ¼ W	Corning	02397740
R54	Same as R1		
R55	Same as R10		
R56	Resistor, fixed, 62 kΩ ±5%, ¼ W	AB	02355040
R57	Resistor, fixed, 1 MΩ ±5%, ¼ W	AB	02355330
R58	Same as R7		
R59	Same as R36		
R60	Same as R5		
R61	Same as R36		
R62	Same as R56		
R63	Same as R7		
R64	Same as R36		
R65	Same as R14		
R66	Same as R7		
R67	Resistor, fixed, 100 Ω ±5%, ¼ W	AB	02354380
R68	Resistor, fixed, 30 kΩ ±5%, ¼ W	AB	02354960
R69	Same as R27		
R70	Same as R13		
R71	Same as R13		
R72	Same as R43		
R73	Same as R10		
R74	Resistor, fixed, 3.9 kΩ ±5%, ¼ W	AB	02354750

Table 6-8. Input Amplifier Assembly A7 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, .1 μF, 1.2 kV	Elpac	03286130
C2	Capacitor, fixed, 0.1 μF, 100 V	TRW	03286680
C3	Capacitor, fixed, 50 pF 500 V	Elmenco	03289020
C4	Capacitor, fixed, 0.0022 μF, 100 V	TRW	03286690
C5	Capacitor, variable, 0.5 - 4.5 pF	JFD	03270200
C6	Capacitor, fixed, 10 μF, 20 V	Sprague	03279100
C7	Capacitor, fixed, 0.01 μF, 200 V	TRW	03278910
C8	Capacitor, fixed, 39 μF, 10 V	Sprague	03287630
C9	Capacitor, fixed, 0.0022 μF, 200 V	TRW	03278860
C10	Capacitor, fixed, 0.022 μF, 200 V	TRW	03278930
C11	Capacitor, fixed, 0.1 μF, 200 V	TRW	03278960
C12	Same as C8		
C13	Same as C7		
C14	Capacitor, fixed, 150 pF, 300 V	Elmenco	03281360
C15	Capacitor, fixed, 360 pF, 500 V	Elmenco	03281460
C16	Capacitor, fixed, 47 pF, 300 V	Elmenco	03175190
C17	Same as C7		
C18	Capacitor, fixed, 75 pF, 300 V	Elmenco	03175250
C19	Same as C18		
C20	Capacitor, fixed, 0.0047 μF, 200 V	TRW	03278880
C21	Same as C7		
C22	Capacitor, fixed, 300 pF, 300 V	Elmenco	03281440
CR1	Diode, 1N965B	FS	26014250
CR2	Same as CR1		
CR3 through CR8	Diode, FD300	FS	26012320
CR9 through CR13	Diode, FD100	FS	26006930
CR14	Same as Q1		
CR15	Same as Q1		
K1	Switch, reed	IBM	05034910
LK1	Coil, relay U32-P	Coto Coil	21103130
Q1	Transistor, 2N3694	FS	26012660
Q2	Transistor, 2N4120	FS	26014410
Q3	Transistor, 2N4250	FS	26014430
Q4	Transistor, 2N3565	FS	26012000
Q5	Same as Q3		
Q6	Same as Q3		

Table 6-8. Input Amplifier Assembly A7 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
Q7	Transistor, 2N3568	FS	26014360
Q8	Transistor, S17395	FS	26003741
Q9	Same as Q8		
Q10	Same as Q4		
Q11	Transistor, 2N4249	FS	26013260
Q12	Same as Q7		
Q13	Transistor, 2N1893	FS	26007250
Q14	Transistor, 2N4032	FS	26012730
Q15	Transistor, 2N4121	FS	26012650
Q16	Same as Q4		
Q17	Same as Q4		
Q18	Same as Q4		
Q19	Not assigned		
Q20	Not assigned		
Q21	Same as Q8		
Q22	Same as Q8		
R1	Resistor, fixed, 6.8 kΩ ±5%, ¼ W	AB	02354810
R2	Same as R1		
R3	Resistor, fixed, 100 kΩ ±5%, ¼ W	AB	02355090
R4	Resistor, fixed, 220 kΩ ±5%, 2 W	AB	02037040
R5	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R6	Resistor, fixed, 1 kΩ ±5%, ¼ W	AB	02354620
R7	Same as R6		
R8	Resistor, fixed, 30 kΩ ±5%, ¼ W	AB	02354960
R9	Same as R3		
R10	Resistor, fixed, 120 kΩ ±5%, ¼ W	AB	02355110
R11	Same as R10		
R12	Resistor, fixed, 33 kΩ ±5%, ¼ W	AB	02354970
R13	Resistor, fixed, 200 kΩ ±5%, ¼ W	AB	02355160
R14	Same as R3		
R15	Same as R3		
R16	Resistor, fixed, 2.2 MΩ ±5%, ¼ W	AB	02355410
R17	Same as R16		
R18	Same as R5		
R19	Resistor, fixed, 2.7 Ω ±5%, ¼ W	AB	02354000
R20	Resistor, fixed, 22 kΩ ±5%, ¼ W	AB	02354930
R21	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R22	Same as R5		
R23	Resistor, fixed, 470 kΩ ±5%, ¼ W	AB	02355250
R24	Same as R23		
R25	Same as R12		

Table 6-8. Input Amplifier Assembly A7 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
R26	Same as R16		
R27	Resistor, fixed, 10 MΩ ±5%, ¼ W	AB	02355570
R28	Resistor, fixed, 620 kΩ ±5%, ¼ W	AB	02355280
R29	Resistor, fixed, 360 kΩ ±5%, ¼ W	AB	02355220
R30	Same as R27		
R31	Not assigned		
R32	Resistor, variable, 10 kΩ, ¾ W	Beckman	01110290
R33	Not assigned		
R34	Resistor, fixed, 2 kΩ ±5%, ¼ W	AB	02354680
R35	Resistor, fixed, 5.1 kΩ ±5%, ¼ W	AB	02354780
R36	Resistor, fixed, 470 Ω ±5%, ¼ W	AB	02354540
R37	Resistor, fixed, 3.3 kΩ ±5%, ¼ W	AB	02354730
R38	Same as R3		
R39	Same as R5		
R40	Same as R35		
R41	Resistor, fixed, 220 Ω ±5%, ¼ W	AB	02354460
R42	Same as R41		
R43	Same as R20		
R44	Same as R5		
R45	Same as R3		
R46	Same as R5		
R47	Same as R20		
R48	Same as R20		
R49	Same as R20		
R50	Same as R23		
R51	Same as R23		
R52	Same as R5		
R53	Resistor, fixed, 3.9 kΩ ±5%, ¼ W	AB	02354700
R54	Same as R53		
R55	Resistor, fixed, 1 kΩ ±.01%, .3 W	Vishay	02398650
R56	Resistor, fixed, 9 kΩ ±.01%, .3 W	Vishay	02398640
R57	Resistor, fixed, 4.7 MΩ ±5%, ½ W	Amperex	02031360
R58	Resistor, variable, 100 Ω, ¾ W	Beckman	01110230
	Miscellaneous		
K1	Reed, switch		05034670
	Transipad, TO-5	Milton	41012340
LK1	Coil, relay U32P	Coto-Coil	21103130

Table 6-9. DC Attenuator Assembly A8 Parts List

Circuit Ref.	Description	Manufacturer	Number
CR1	Diode, 1N827	FS	26013960
CR2	Diode, FD 100	FS	26006930
CR3	Same as CR2		
K1	Switch, reed, vacuum 1.5	Gordos	05036150
K2	Reed, 17.5-32.5	IBM	05033810
K3	Same as K2		
K4	Same as K1		
K5	Same as K2		
LK1	Coil, relay, SP24P	Coto-Coil	21103060
LK2	Coil, relay, U32P	Coto-Coil	21103130
LK3	Same as LK2		
LK4	Same as LK1		
LK5	Same as LK2		
Q1 through Q4	Transistor, 2N3694	FS	26012660
R1	Resistor, fixed, 100 kΩ ±5%, 1 W	AB	02033960
R2	Resistor, fixed, 9.85 MΩ ±.25%, 2 W	IRC	02399340
R3	Resistor, variable, 1 kΩ	Beckman	01110260
R4	Resistor, fixed, 90 kΩ ±.25%, ½ W	IRC	02399320
R5	Resistor, variable, 100 Ω	Beckman	01110230
R6	Resistor, fixed, 10 kΩ ±.25%, 2 W	IRC	02399350
R7	Resistor, fixed, 110 kΩ ± 5%, 1 W	AB	02033970
R8	Resistor, fixed, 10 kΩ ±.25%, 1/8 W	IRC	02399360
R9	Resistor, variable, 2 kΩ	Beckman	01110270
R10	Resistor, fixed, 54.9 kΩ ±1%, 1/8 W	IRC	02374630
R11	Resistor, fixed, 2.4 kΩ ±5%, ½ W	AB	02030570
R12 through R16	Resistor, fixed, 22 kΩ ±5%, ¼ W	AB	02354930
R17	Resistor, fixed, 30 kΩ ±5%, ¼ W	AB	02354960
R18	Same as R17		
R19	Same as R17		
R20	Same as R17		
R21	Resistor, fixed, 10 Ω ±5%, ¼ W	AB	02354140
	Miscellaneous		
	Shield Relay Reed, small		42025811
	Shield Relay Reed, large		42025801

Table 6-10. AC to DC Converter Assembly A9 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
R3	Resistor, fixed, 9.76 kΩ ±1%, 1/8 W		02394830
R4	Same as R1		
R5	Resistor, fixed, 374 kΩ ±1%, 1/8 W		02417190
R6	Resistor, variable, 50 kΩ		01111380
R7	Resistor, fixed, 41.2 kΩ ±1%, 1/8 W		02394820
R8	Resistor, variable 5 kΩ		01111370
R9	Resistor, fixed, 4.7 kΩ ±5%, ¼ W	AB	02354770
R10	Resistor, fixed, 200 Ω ±5%, ¼ W	AB	02354450
R11	Resistor, fixed, 12 kΩ ±5%, ¼ W	AB	02354870
R12	Resistor, fixed, 8.2 kΩ ±5%, ¼ W	AB	02354830
R13	Resistor, fixed, 6.8 kΩ ±5%, ¼ W	AB	02354810
R14	Resistor, fixed, 20 Ω ±5%, ¼ W	AB	02354210
R15	Same as R14		
R16	Resistor, fixed, 120 kΩ ±5%, ¼ W	AB	02355110
R17	Same as R16		
R18	Resistor, fixed, 1 kΩ ±5%, ¼ W	AB	02354620
R19	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R20	Resistor, fixed, 22 MΩ ±5%, ¼ W	AB	02355650
R21	Resistor, fixed, 68 kΩ ±5%, ¼ W	AB	02355050
R22	Same as R11		
R23	Resistor, fixed, 15 kΩ ±5%, ¼ W	AB	02354890
R24	Same as R23		
R25	Resistor, fixed, 2.4 kΩ ±5%, ¼ W	AB	02354700
R26	Resistor, fixed, 390 Ω ±5%, ¼ W	AB	02354520
R27	Resistor, fixed, 3.9 kΩ ±5%, ¼ W	AB	02354750
R28	Resistor, fixed, 470 Ω ±5%, ¼ W	AB	02354540
R29	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R30	Resistor, fixed, 3 kΩ ±5%, ¼ W	AB	02354720
R31	Resistor, fixed, 2.87 kΩ ±1%, 1/8 W		02394810
R32	Same as R29		
R33	Same as R29		
R34	Resistor, fixed, 511 Ω ±1%, 1/8 W		02394840
R35	Resistor, fixed, factory selected — 1 MΩ ±5%, ¼ W	AB	02355330
	— 1.5 MΩ ±5%, ¼ W	AB	02355370
	— 2 MΩ ±5%, ¼ W	AB	02355400
R36	Resistor, fixed, 5.6 Ω ±5%, ¼ W	AB	02354080
R37	Resistor, fixed, 22 kΩ ±5%, ¼ W	AB	02354930
R38	Same as R37		
R39	Same as R37		
R40	Same as R37		
R41	Resistor, fixed, 30 kΩ ±5%, ¼ W	AB	02354960
R42	Same as R41		
R43	Same as R41		
R44	Resistor, fixed, 51 Ω ±5%, ¼ W	AB	02354310

Table 6-10. AC to DC Converter Assembly A9 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
C25	Same as C20		
C26	Not assigned		
C27	Not assigned		
C28	Capacitor, fixed, 2.2 μF, 20 V	Sprague	03281950
C29	Same as C20		
CR1	Diode, FD300	FI	26012320
CR2	Same as CR1		
CR3	Diode, HPA2900		26015360
CR4	Same as CR3		
CR5	Diode, FD100	FS	26006930
CR6	Same as CR5		
CR7	Same as CR5		
CR8	Diode, 1N486B		26015330
K1	Reed, switch		05036330
K2A	Same as K1		
K2B	Same as K1		
K3	Reed, switch		05034910
K4	Same as K3		
L1	Inductor, factory selected – 22 μH, 10%		21103350
	– 10 μH, 10%		21103360
	– 15 μH, 10%		21103370
	– 18 μH, 10%		21103380
	– 27 μH, 10%		21103390
LK1	Coil, Min, U32P	Coto-Coil	21103130
LK2	Coil, reed relay		21103070
LK3	Same as LK1		
LK4	Same as LK1		
Q1A	Transistor, 2N3958		26015100
Q1B	Same as Q1A		
Q2	Transistor, 2N4917	FS	26014620
Q3	Transistor, 2N4250	FI	26014430
Q4	Same as Q3		
Q5	Transistor, 2N3694	FI	26012660
Q6	Same as Q5		
Q7	Same as Q2		
Q8	Same as Q2		
Q9	Same as Q5		
Q10	Same as Q5		
Q11	Same as Q5		
R1	Resistor, fixed, 1 MΩ ±1%, 2 W		02417180
R2	Resistor, variable, 1 kΩ	Beckman	01111620

Table 6-10. AC to DC Converter Assembly A9 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, .1 μF, 1.2 kV	Elpac	03286130
C2	Capacitor, fixed, factory selected – 12 pF, 500 V	Elmenco	03175070
	– 18 pF, 500 V	Elmenco	03175090
C3	Capacitor, fixed, factory selected – 12 pF, 500 V	Elmenco	03175070
	– 18 pF, 500 V	Elmenco	03175090
C4	Capacitor, variable, .8 - .4, .5 pF		03289630
C5	Capacitor, fixed, 560 pF, 300 V	Elmenco	03281520
C6	Capacitor, fixed, factory selected – 270 pF, 500 V	Elmenco	03281430
	– 91 pF, 500 V	Elmenco	03281310
	– 430 pF, 500 V	Elmenco	03281480
C7	Capacitor, fixed, factory selected – 12 pF, 500 V	Elmenco	03175070
	– 18 pF, 500 V	Elmenco	03175090
C8	Capacitor, variable, 2-180 pF		03289350
C9	Capacitor, fixed, factory selected – 27 pF, 500 V	Elmenco	03175130
	– 33 pF, 500 V	Elmenco	03175150
	– 22 pF, 500 V	Elmenco	03175110
	– 39 pF, 500 V	Elmenco	03175170
C10	Capacitor, fixed, factory selected – 27 pF, 500 V	Elmenco	03175130
	– 22 pF, 500 V	Elmenco	03175110
	– 39 pF, 500 V	Elmenco	03175170
	– 33 pF, 500 V	Elmenco	03175150
C11	Capacitor, fixed, factory selected – 27 pF, 500 V	Elmenco	03175130
	– 33 pF, 500 V	Elmenco	03175150
	– 22 pF, 500 V	Elmenco	03175110
	– 39 pF, 500 V	Elmenco	03175170
C12	Capacitor, variable, .8 - 18 pF		03289640
C13	Capacitor, fixed, factory selected – 15 pF, 500 V	Elmenco	03175080
	– 5 pF, 500 V	Elmenco	03175050
	– 27 pF, 500 V	Elmenco	03175130
C14	Capacitor, fixed, factory selected – 91 pF, 500 V	Elmenco	03281310
	– 160 pF, 500 V	Elmenco	03281370
	– 240 pF, 500 V	Elmenco	03281410
C15	Not assigned		
C16	Capacitor, variable,1 - 90 pF		03289360
C17	Capacitor, fixed, 15 pF, 500 V	Elmenco	03175080
C18	Capacitor, fixed, 10 F, 100 V		03289410
C19	Capacitor, fixed, 47 μF, 6 V		03282440
C20	Capacitor, fixed, 1.0 μF, 35 V	Sprague	03282660
C21	Capacitor, fixed, 180 pF, 500 V	Elmenco	03281380
C22	Capacitor, fixed, 6.8 μF, 35 V	Sprague	03282710
C23	Capacitor, fixed, 47 μF, 20 V		03289400
C24	Same as C19		

Table 6-11. Ohms Converter Assembly A10 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, .01 μF, 200 V	TRW	03278910
C2	Same as C1		
C3	Capacitor, fixed, 100 pF, 500 V	Elmenco	03281320
CR1	Diode, FD100	FS	26006930
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Diode, 1N486A	FS	26014570
CR5	Diode, 1N827	FS	26013960
K1	Switch, reed	IBM	05034910
LK1	Coil, relay MIN U32P	Coto-Coil	21103130
Q1	Transistor, 2N2920	FS	26011350
Q2	Transistor, 2N3565	FS	26012000
Q3	Same as Q2		
Q4	Transistor, 2N4250	FS	26014430
Q5	Same as Q2		
Q6	Same as Q2		
Q7	Same as Q1		
R1	Resistor, fixed, 1 MΩ ±5%, ¼ W	AB	02355330
R2	Resistor, fixed, 4.7 MΩ ±5%, ¼ W	AB	02355490
R3	Resistor, fixed, 6.8 kΩ ±5%, ¼ W	AB	02354810
R4	Resistor, fixed, 510 Ω ±5%, ¼ W	AB	02354550
R5	Resistor, fixed, 1 kΩ ±5%, ¼ W	AB	02354620
R6	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R7	Resistor, fixed, 100 kΩ ±5%, ¼ W	AB	02355090
R8	Resistor, variable, 200 Ω, ¾ W	Beckman	01110240
R9	Same as R6		
R10	Same as R6		
R11	Resistor, fixed, 10 kΩ ±.1%, .3 W	Vishay	02398660
R12	Resistor, fixed, 150 Ω ±1%, 1/10 W	IRC	02394760
R13	Resistor, fixed, 301 Ω ±1%, 1/10 W	IRC	02394770
R14	Resistor, fixed, 475 Ω ±1%, 1/10 W	IRC	02394750
R15	Resistor, fixed, 2.2 MΩ ±5%, ¼ W	AB	02355410
R16	Same as R6		
R17	Resistor, fixed, 39 kΩ ±5%, ¼ W	AB	02354990
R18	Resistor, fixed, 6.5 kΩ ±.1%, .30 W	Vishay	02403000
R19	Same as R3		
R20	Resistor, fixed, 43 kΩ ±5%, ¼ W	AB	02355000
R21	SAme as R6		
	Shield, Relay Reed	FI	42025811

Table 6-12. Jumper Board Assembly A11 Parts List

Circuit Ref.	Description	Manufacturer	Number
	This board contains no components and is used when A14 (current shunts) is not used.		

Table 6-13. Power Regulator Assembly A12 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 64 μF, 64 V	Amperex	02386620
C2	Capacitor, fixed, 1 μF, 35 V	Fansteel	03279130
C3	Same as C2		
C4	Same as C1		
C5	Same as C1		
C6	Same as C1		
C7	Same as C2		
C8	Same as C2		
C9	Capacitor, fixed, 39 μF, 10 V	Sprague	03287630
CR1	Diode, FD100	FS	26006930
CR2	Diode, 1N754A	FS	26014220
CR3	Diode, 1N4003	Motorola	26011080
CR4	Diode, 1N758A	FS	26012550
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR3		
CR9	Same as CR1		
CR10	Same as CR2		
CR11	Same as CR3		
Q1	Transistor, SE7005	FS	26003571
Q2	Transistor, 2N3565	FS	26012000
Q3	Same as Q2		
Q4	Same as Q2		
Q5	Transistor, 2N4250	FS	26014430
Q6	Same as Q5		
Q7	Transistor, 2N3072	FS	26008560
Q8	Same as Q5		
Q9	Transistor, 2N3055	FS	26012140
Q10	Same as Q2		
Q11	Same as Q2		
Q12	Same as Q2		
Q13	Same as Q2		
Q14	Transistor, 2N1893	FS	26007250
Q15	Same as Q1		
Q16	Same as Q2		
Q17	Same as Q2		
Q18	Same as Q5		
Q19	Same as Q7		
Q20	Same as Q5		
R1	Resistor, fixed, 390 kΩ ±5%, ¼ W	AB	02355230

Table 6-13. Power Regulator Assembly A12 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
R2	Resistor, fixed, 10 Ω ±5%, ¼ W	AB	02354140
R3	Resistor, fixed, 1.2 kΩ ±5%, ¼ W	AB	02354640
R4	Resistor, fixed, 10 kΩ ±5%, ½ W	AB	02030720
R5	Resistor, fixed, 6.2 kΩ ±5%, ¼ W	AB	02354800
R6	Resistor, fixed, 270 Ω ±5%, ½ W	AB erex	02030340
R7	Resistor, fixed, 150 Ω ±5%, 2 W	AB	02036280
R8	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R9	Same as R8		
R10	Resistor, fixed, 22 kΩ ±5%, ¼ W	AB	02354930
R11	Resistor, fixed, 3 kΩ ±5%, ½ W	AB	02030590
R12	Same as R3		
R13	Same as R2		
R14	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R15	Resistor, fixed, 7.5 kΩ ±2%, ¼ W	Amperex	02397590
R16	Resistor, fixed, 750 Ω ±5%, ¼ W	AB	02354590
R17	Resistor, fixed, 1.8 kΩ ±5%, ¼ W	AB	02354670
R18	Resistor, fixed, 18 kΩ ±2%, ¼ W	Corning	02397680
R19	Resistor, fixed, 5.1 kΩ ±5%, ¼ W	AB	02354780
R20	Same as R4		
R21	Resistor, fixed, 39 kΩ ±5%, ¼ W	AB	02354990
R22	Same as R21		
R23	Same as R10		
R24	Resistor, fixed, 1.0 Ω ±5%, ½ W	AB	02420690
R25	Resistor, fixed, 1 kΩ ±5%, ¼ W	AB	02354620
R26	Resistor, fixed, 8.2 kΩ ±5%, ¼ W	AB	02354830
R27	Resistor, fixed, 3.6 kΩ ±5%, ½ W	AB	02030610
R28	Resistor, fixed, 200 Ω ±5%, ¼ W	AB	02354450
R29	Same as R3		
R30	Resistor, fixed, 24 kΩ ±5%, ½ W	AB	02030810
R31	Same as R26		
R32	Same as R26		
R33	Resistor, fixed, 6.2 kΩ ±5%, ½ W	AB	02030670
R34	Resistor, fixed, 27 Ω ±5%, ¼ W	AB	02354240
R35	Same as R3		
R36	Same as R8		
R37	Same as R8		
R38	Same as R3		
R39	Same as R34		
R40	Resistor, fixed, 6.8 kΩ ±2%, ¼ W	Corning	02397580
R41	Resistor, fixed, 680 Ω ±5%, ¼ W	AB	02354580
R42	Resistor, fixed, 1.5 kΩ ±5%, ¼ W	AB	02354650
R43	Resistor, fixed, 15 kΩ ±2%, ¼ W	Corning	02397660
R44	Same as R14		

Table 6-13. Power Regulator Assembly A12 Parts List (Continued)

Circuit Ref.	Description	Manufacturer	Number
R45	Same as R19		
R46	Same as R4		
R47	Same as R4		
TP1	Test jack, red	Carter	09062520
TP2	Test jack, orange	Carter	09062530
TP3	Test jack, green	Carter	09062550
TP4	Test jack, blue	Carter	09062560
TP5	Test jack, violet	Carter	09062570
TP6	Test jack, yellow	Carter	09062540
TP7	Test jack, white	Carter	09062590
TP8	Test jack, brown	Carter	09062510
TP9	Test jack, black	Carter	09062500

Table 6-14. Mother Board Assembly A13 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 80 μF, 300 V	Sangamo	03289120
C2	Capacitor, fixed, 2X650 μF, 50 V	Sangamo	03280190
C3	Same as C2		
C4	Capacitor, fixed, 1200 μF, 25 V	Sangamo	03281990
C5	Same as C2		
C6	Same as C2		
CR1 through CR14	Diode, 1N4005	Motorola	26012270
CR15	Diode, 1N486B		26015330
R1	Resistor, fixed, 100 kΩ ±5%, ½ W	AB	02030960
R2	Resistor, fixed, 51 kΩ ±5%, 2 W	AB	02036890
XA1	Not assigned		
XA2	Connector, 22 pin Dual	Cinch	09064930
XA3	Same as XA2		
XA4	Connector, 12 pin Dual	Cinch	09064940
XA5	Same as XA4		
XA6 through XA9	Same as XA2		
XA10	Same as XA4		
XA11	Same as XA4		
XA12	Same as XA2		

Table 6-15. Current Shunts Assembly A14 Parts List

Circuit Ref.	Description	Manufacturer	Number
CR1 through CR8	Diode, 1N4003	Motorola	26011080
CR9	Diode, FD100	FS	26006930
CR10	Same as CR9		
CR11 through CR15	Same as CR9		
CR16	Diode, 1N486A	FS	26014570
K1	Reed, switch	Gordos	05036150
K2	Reed, switch	IBM	05036220
K3A	Same as K2		
K3B	Same as K2		
K4A	Same as K2		
K4B	Same as K2		
K5	Same as K2		
LK1	Coil, relay SD24P		21103060
LK2	Coil, relay, U32P		21103130
LK3	Coil, relay, dual UD32P		21103070
LK4	Same as LK3		
LK5	Same as LK2		
Q1	Transistor, 2N3694	FS	26012680
Q2	Same as Q1		
Q3	Same as Q1		
R1	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R2	Same as R1		
R3	Resistor, fixed, 1.10 Ω ±1%, 7 W	Dale	02401070
R4	Resistor, fixed, 9.53 Ω ±1%, ¼ W	Dale	02393980
R5	Resistor, variable, 10 Ω	Beckman	01110200
R6	Resistor, fixed, 11.5 Ω ±1%, .125 W	Dale	02398480
R7	Resistor, fixed, 63.4 Ω ±1%, .125 W	IRC	02399410
R8	Resistor, variable, 100 Ω	Beckman	01110230
R9	Resistor, fixed, 127 Ω ±1%, .125 W	IRC	02398500
R10	Resistor, fixed, 634 Ω ±1%, .125 W	IRC	02398540
R11	Resistor, variable, 1 kΩ	Beckman	01110260
R12	Resistor, fixed, 1.15 kΩ ±1%, .125 W	IRC	02399420
R13	Resistor, fixed, 5.62 kΩ ±1%, .125 W	IRC	02399400
R14	Resistor, variable, 10 kΩ	Beckman	01110290
R15	Resistor, fixed, 220 Ω ±5%, ¼ W	AB	02354460
R16	Resistor, fixed, 30 kΩ ±5%, ¼ W	AB	02354960
R17	Same as R16		
R18	Same as R16		

Table 6-16. Preamplifier Assembly A15 Parts List

Circuit Ref.	Description	Manufacturer	Number
AK1	Coil, relay, U32P	Coto-Coil	21103130
QA1	Amplifier, AD026B		91005000
C1	Capacitor, fixed, .1 μF, 50 V		03284430
CR1	Diode, FD300	FS	26012320
CR2	Same as CR1		
CR3	Diode, Zener, 1N758A	FS	26012550
CR4	Same as CR3		
CR5	Diode, FD100	FI	26006930
CR6	Diode, 1N486B	FS	26015330
K1	Reed, relay, MRMF2	Hamlin	05036220
R1	Resistor, fixed, 51 kΩ ±5%, 2 W	Hopkins	02036890
R2	Resistor, fixed, 10 kΩ ±5%, ½ W	AB	02030720
R3	Resistor, fixed, 1 kΩ ±.1% .20 W	RCL	02420770
R4	Resistor, fixed, 1.3 MΩ ±5%, ¼ W	AB	02355360
R5	Resistor, fixed, 2.7 Ω ±5%, ¼ W	AB	02354000
R6	Resistor, variable, 10 kΩ	Beckman	01110290
R7	Resistor, fixed, 9 kΩ ±.1% .20 W	RCL	02420780
R8	Resistor, variable, 500 Ω	Beckman	01110220

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